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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXII, No. 8 NOVEMBER, 1922 WHOLE No. 190

THE DEVELOPMENT OF PERSONALITY AND THE CONSCIOUSNESS OF SELF.

BY ELLIS R. WEAVER,

Northwestern University, Evanston, Ill.

The ultimate standard of value among human beings is personality; hence its development is of the greatest importance. But in order to understand the similarities and the minute differences between "Personality" and "Consciousness of Self," a definition of the terms is necessary.

Ribot gives a concise definition of the former by saying that personality is the highest form of psychic individuality and is a concrete whole. Spencer says that it cannot be expressed in terms of matter, but only in spiritual terms and therefore a definition is practically impossible. Carlyle says, "Believe it you must, but you cannot understand it." Even this is somewhat true, it is possible to give the elements of personality and their relationship.

The basal elements of personality are self-consciousness and self-identity. Human will is the immediate expression of the whole personality, that is, the self deliberating, choosing, and acting, on the individual's own motion. In connection with this Kant says, "Will is a casuality belonging to human beings and freedom is the property of causality which makes them efficient and independent.

From this it seems that self-consciousness or the consciousness of self, of which I make no distinction, is only an element of personality and that the development of the latter must include the development of the former. In connection with this Kirkpatric says, "Each human mind is a unity complete in itself and that the consciousness of self is the awareness of conscious states produced by physiological processes and sensory motor reactions." Professor James explains that the empirical self in each of us is what each individual is tempted to call by

the name "Me," or that a man's self is all that he can call his. The constituents of self are feelings and the emotions that they arouse, and actions which are prompted by these emotions.

According to M. Bergson there is no rigid, immutable substance in personality but there is a simple continuous melody of our inner life, a melody which runs on from the beginning to the end of our child existence. This, and nothing else is our personality. Accordingly, I will treat the consciousness of self as an element of personality.

After the first two weeks of a baby's life, the eyes cease to wander altogether helplessly but rather stop and cling to the bright surfaces and by the end of the month the infant seems to be conscious of jars and noises. There seems to be a recognition between that of being alone and that of companionship. Although this is not self consciousness it is a definite step in that direction. It is the first great stepping stone to personality, although small. At this time, according to Kirkpatric, the field of consciousness soon to become a fairyland of new experiences, is a half-formed desert with only an occasional rock of bodily pain or an oasis of comfort clearly discernible.

By the end of the second month the emotional life begins to awaken, as we are able to see by his fright or by his look of surprise at his own crowing, a tendency toward emotion. Perez and Sulley seem to think that anger is shown before fear, perhaps as early as the first week of life. Others believe that memory begins at the beginning of the second month, that the memory of faces is getting more and more clear, that an accidental splash in the water is followed the next day by one that is intentional. Emotional life is more strongly expressed in the child's delight in tumbling and being gently tumbled about. In a short time, the baby begins to learn the shapes of objects by his grasp and is continually in search of different things. This is another step in the distinction of bodies and leads directly to the distinction of self and therefore a small advance to personality.

The sixth month is the beginning of the learning of the senses and of the poise of the body. The remainder of the first year is thus spent in research work, that is, working on new problems each day and thereby, in a very definite manner, becoming acquainted with the body in which he lives. He gradually gets control of this body and perhaps begins to imitate. In a short time he thinks and it is this time that the conscious state begins to make its first appearance. The infant is begin-

ning to know himself although in nothing more than the physical self.

Professor James says that the first sensation that an infant gets is for him the Universe. Later he comes to know that the Universe is nothing but the amplification of the first simple germ which, by acreation, has grown so big that its first estate is unrememberable. In his awakening to consciousness of a mere "This" an object is encountered finally which has objectivity, unity, substantiality and causality in quite a full sense. In the first five months the infant lays the foundation of knowledge. In the seven months following he is trying to find out something of himself and of his environment. In other words he is getting the fundamental concepts. At the age of six months, the baby is beginning to have an idea of cause and effect and can somewhat appreciate the value of human intercourse. He is discovering his own ego and its relationship with other individuals of his own species.

Mentally, the child is in somewhat the same condition as that of a man who suddenly finds himself in a shop where all kinds of new machines are being operated. Although at first the individual knows no more about one than the other, he learns by noticing their movements that he can control them. In the same sense the baby learns to control his movements, and the conscious states that are experienced are organized into a conscious self. Previous to this time mental freedom has been wholly lacking, but the degree in which this is developed is regarded as a good measure of the mental development. This, in other words, is only saying, "Will is a causality belonging to human beings and freedom is the property of causality which makes the individual efficient and independent. Human personality is entirely lacking if the individual is not independent, that is, not self-directing and self-governing.

The previous condition of the child from birth to one year of age is rightfully called the presocial stage and is characterized by the acquaintance of the child to his physical self. During the following period, the imitating and socializing period, there is a further development probably accomplishing more than any other corresponding length of time, that is, two years.

The first noticeable step in this period is the child's perception between himself as a thinking and a willing power, and his own body which obeys that will. It is the beginning of the distinctions between self and non-self. If our will never resisted,

if matter moulded itself to every action we made, if nature took the course we desired, if there were no feeling of otherness, then the individual would lack selfconsciousness. Such is the experience of a child from one to six years of age while he constantly meets resistance.

During the last part of the second year of the child's life and more distinctly during the third year, the child ceases to call itself by the second person and uses the first instead. The idea of an individuality grows and is greatly inforced when he has a certain amount of responsibility placed upon him. He has rational thoughts which create language, so we find at this time that the vocabulary is rapidly growing.

In this there are the traces of more than personality or self-consciousness. Memory is beginning and memory testifies to the reality of personality. In recognition and in memory is expressed an inner unity to which the material world affords no parallel. The succession of feelings which is called memory is that by which individuals distinguish themselves. John S. Mill asserts that speech is the distinctive mark of man and determines personality.

So it is with the imitative age of the child. He has learned the use of speech, he is beginning to distinguish "Self" from the outside world and to form a connective memory. Gradually he is developing a personality from its elements, a self-consciousness and a self-identity, although it is more of a human than an individual personality.

After the age of three years is passed, the child comes in contact with a larger number of persons and his mental development is greatly increased. He has already organized his mental material into a consciousness of self and therefore has a wider and a better control over his mental life. He is becoming independent of persons and things. He is acquiring a distinct personality ever desiring to experience new states of consciousness either in imagination or in reality. Although he is still imitating the people around him he is making a selection of them that are desirable to him and discarding the rest. He is developing the human personality into one more of an individual type. This is evident from the fact that all children are more or less contrary. They are at this time filled with self assertion. Occasionally this development takes place without any serious breaks with other personalities but such is not usually the case.

In selecting his own actions the child broadens his person-

ality and in so doing must of necessity learn what self control means. He has by this time developed a strong or a more passive personality in comparison to his age and must be handled accordingly. His common consciousness must be preserved and at the same time his individuality must be allowed to develop fully. Language still acts as a great factor in the further development. The higher type of memory now evident shows a higher personality.

The following period, that of competitive socialization, (age from six to twelve) does not stand out as the previous years. So completely does the child develop his personality that it is retained with very little change. The child of six differs very little from the one of twelve. His personality is in competition with those who are of about the same age rather than those of adults as has been true of the preceding three periods. He thus adds characters of other personalities to his and broadens his individual development. He is gaining a little more than the ordinary common consciousness and at the same time is gaining in self control. The consciousness of the child's own insufficiency brings him to a consciousness of the objective values in his environment.

During this period there is a refinement of the child's power of perception. He gradually learns to analyze and thus begins to see things in a much keener light. His confidence in himself is increased and accordingly his will power is strengthened.

We now come to a period much different from any before this. This is the early adolescent period and usually extends from the age of twelve to that of eighteen years. The conscious life of the individual is so changed that perhaps it is possible to say that it is somewhat like the third period when the conscious self is beginning.

The great problem of the youth of this time is that of finding himself in the world of work, social enjoyment and duty that surrounds him. This is not entirely a problem of adjustment but as much a problem of building a new personality in which he must fuse all that is vital around him with that which is original in himself, for something new is brought into the world by each individual. The normal adolescent keenly feels the impulse to be himself, to question all traditions and to think things out for himself. Even though his conclusions are seldom different from those made before his time, it is through this impulse to think for himself that he gradually finds himself. This is said

to be an age of dreaming, and it undoubtedly is, for it is the way that he finds his new personality. It is the sex impulse that is the hidden spring for the final development of self. The youth comes to a greater realization of his future, his relation to his friends, both of his own and those of the opposite sex. There is a sudden realization of greater responsibilities which more distinctly emphasize the idea of "Self." He has a distinct individuality characterized and distinguished from the personalities about him.

This undoubtedly marks the end of the development of personality as from this time on there is seldom anything added. He has made his character, has found his "Self" and can from this time be characterized by the individuality which he has formed. We find then first of all that the baby finds his physical self which, of course, is not a part of personality. This leads to the distinct mental self, the beginning of memory and self-identity, which usually comes at the end of the third or the beginning of the fourth years. From this time to the sixth year there is a gradual development of this embryonic personality. During the period of competitive socialization there is very little change, but during adolescence there is a general moulding, and usually an entirely new self and a thinking being is realized.

TALC AND SOAPSTONE IN 1921.

Production.

The production of talc and soapstone in 1921 showed a great decline as compared with that in 1920. The quantity sold was the smallest since 1908 and was about forty per cent less than the average for the five preceding years, according to Edward Sampson, of the United States Geological Survey, Department of the Interior.

The total quantity of talc and soapstone sold in 1921 was 126,000 tons, valued at $1,821,000, as compared with 211,000 tons, valued at $3,035,000, in 1920. This represents a decrease of forty per cent in both quantity and value. Vermont, which since 1917 has been the largest producer, maintained its position by producing thirty-eight per cent of the total quantity. New York produced thirty-three per cent of the quantity sold, but for the first time took second place in the value of its product. Virginia, which produced fourteen per cent of the total, ranked next to New York in quantity, but for the first time led in the value of its output, owing to the fact that the soapstone industry in that state was not nearly so much affected as the ground talc industry, on which the other principal producing states depend.

The production and value by states was as follows: Vermont, 48,648 tons, $438,534; New York, 41,937 tons, $530,154; Virginia, 17,721 tons, $601,878; California, 8,233 tons, $128,188; Pennsylvania and New Jersey, 7,205 tons, $76,912; North Carolina, 731 tons, $17,048; Georgia, Maryland, and Massachusetts, 1,959 tons, $28,737.

CHART OF THE SCIENCES.

By D. H. Selchow and W. Segerblom,
The Phillips Exeter Academy, Exeter, N. H.

Subdivision of the activities of the newly formed Scientific Society in this School into groups suitable for carrying on the work among the members raised the question of just which sciences to select and which to combine for group work. A simple and tentative division was finally decided upon, but the question caused two of the members to consider in some detail all subjects which might properly be included under the general head of "Science" and how they should be grouped. We got together sufficient material to warrant putting it in the form of a large chart to hang on the wall of the Society room. For the present the matter has been typewritten and the different sections of the chart thumb-tacked to a large sheet of compo board; this enabled us to insert the proper lines to show the division and subdivision of the subject-matter. The name of each science or subdivision of a science is accompanied by a suitable definition. Various books on science, some encyclopedias and dictionaries, Herbert Spencer's pamphlet on the classification of the sciences and a recent report of the Washington Academy of Science constituted the chief sources of information.

The main layout of the chart is shown in the accompanying very simple diagram. Under each separate science mentioned in the diagram we have put in the chart itself a rather detailed list of subdivisions with definitions. These different lists are printed in this article as solid text, following the order as given in the diagram.

We do not claim completeness for this chart. Without doubt many readers will differ from us on the selection of titles and on certain definitions. It must be remembered that we could find nothing like this chart in print, so had to judge as best we could and select accordingly.

If there develops a call for this material in printed chart form as we have drawn it up for our wall chart, we shall probably put it in such printed chart form. Any criticisms or suggestions will be gratefully received by the compilers and may be sent to the second named author.

The different lists comprising the chart and following the outline given above are as follows:

SCIENCE is knowledge reduced to order and so classified and arranged as to be easily remembered, readily referred to and advantageously applied.

- Science
  - Knowledge of Space and Time
    - Mathematics
  - Knowledge of Matter and Energy
    - Astronomy
    - Physics
    - Chemistry
    - Physiography
      - Geology
      - Geography
  - Knowledge of Matter, Energy and Life
    - Botany
    - Zoology
    - Anatomy
  - Knowledge of Mankind
    - Knowledge of Physical Man
      - Anthropology
    - Knowledge of Mind
      - Philosophy
      - Logic
      - History
    - Knowledge of Society
      - Ethnology
      - Political Economy
      - Philology

No one classification of the sciences is wholly satisfactory, so much depends upon the point of view.

Sosman says: "Science is not divisible sharply into little compartments labelled Chemistry, Botany and the like. There is one vast field of human knowledge, and facts concerning any part of that field have a bearing on every other part."

Comte classified sciences in order ranging from those dealing with the simplest phenomena to those dealing with the most complex, e. g. from mathematics to sociology.

Spencer classified sciences into three groups: the abstract (e. g. mathematics), the abstract-concrete (e. g. mechanics), and the concrete (e. g. geology).

A later classification divides the sciences into the Theoretical Sciences and the Practical Sciences.

In any system there is bound to be a certain amount of overlapping of subjects.

The main purpose of the classification presented below is to give a bird's-eye view of the field covered by scientific effort.

KNOWLEDGE OF SPACE AND TIME comprises the first of the four big subdivisions and includes only mathematics.

MATHEMATICS: The science of quantity. Further subdivided into:

Mensuration, the art of measuring or determining quantity.
Arithmetic, the science of numbers and art of computation.
Algebra, the science which employs letters in reasoning about numbers.
Plane Geometry, the science of figures in space of two dimensions.
Solid Geometry, the science of figures in space of three dimensions.

Descriptive Geometry, the theory of making projections of figures on two planes.

Analytical Geometry, geometry in which lines, planes and solids are represented by algebraic symbols and equations.

Plane Trigonometry, treats of the relations of the sides and angles of plane triangles.

Analytical Trigonometry treats of trigonometric functions by algebraic operations.

Spherical Trigonometry, the computation of spherical triangles.

Differential Calculus, the science of variable quantities.

Integral Calculus deals with the summation of series of differences in variables.

Absolute Calculus, a new branch of mathematics developed in connection with the Einstein theory.

Navigation, the science of directing the course of vessels.

Mechanics. See Physics.

KNOWLEDGE OF MATTER AND ENERGY, sometimes called *Natural Science*, comprises the second of the four big subdivisions. It includes Astronomy, Physics, Chemistry, and Physiography, the last named being subdivided into Geology and Geography.

ASTRONOMY: The science of the heavenly bodies. Further subdivided into:

Solar Astronomy, study of the sun and the planets revolving about it.

Siderial Astronomy, study of heavenly bodies outside the solar system.

Descriptive Astronomy, description of phenomena exhibited by the heavenly bodies.

Practical Astronomy, the study of how to observe these phenomena.

Physical Astronomy, the science of the laws governing the motions of the heavenly bodies.

Nautical Astronomy, that part of astronomy which is applied to navigation.

Spherical Astronomy, the application of geometry and trigonometry to ascertaining the apparent positions of celestial bodies.

Theoretical Astronomy, the investigation of orbits and motions of celestial bodies.

PHYSICS: The science of forces and motions. Further subdivided into the study of:

Mechanics, the mathematical doctrine of the motions and tendencies to motion of particles and systems under the influence of forces and constraints.

Heat, the kinetic energy of molecules.

Thermodynamics treats of the relations between heat and work.

Calorimetry, the measurement of the quantity of heat in thermal units.

Light, the form of energy which acting upon the organs of sight renders visible the objects from which it proceeds.

Optics treats of the nature, properties and behavior of light, and of instruments used in connection therewith.

Sound, the vibration of the air or other medium manifesting itself on the ear.

Acoustics, the study of the cause, nature and phenomena of sound.

Magnetism, the property of attraction and repulsion exhibited by certain substances.

Electricity, the cause of attraction and repulsion and of certain chemical decompositions.
Pneumatics treats of the mechanical properties of gases.
Dynamics, the science of forces.
Statics deals with forces at rest.
Kinematics deals with forces in motion.
Hydrostatics, the mathematical theory of the pressure and equilibrium of incompressible fluids.
Wireless Telegraphy and Wireless Telephony, the transmission of signals by long ether waves.
Electro-Chemistry. See Chemistry.

CHEMISTRY: The science of the composition of substances and changes they undergo. Further subdivided into:

Theoretical Chemistry deals with the laws governing chemical action.
Inorganic Chemistry, the study of inert substances.
Organic Chemistry, the study of the carbon compounds.
Analytical Chemistry, the determination of the composition of substances either qualitatively or quantitatively, or both.
Electrochemistry treats of the behavior of substances when subjected to electricity.
Thermochemistry treats of the relations existing between chemical action and heat.
Physical Chemistry treats of the borderland between Physics and Chemistry.
Applied Chemistry, the application of chemical laws to the arts and manufactures.
Agricultural Chemistry treats of the composition of soils, plants, manures, etc.
Physiological Chemistry treats of tissues and functions of animals and plants.
Pharmaceutical Chemistry treats of plants used as medicines.
Metallurgical Chemistry treats of metals and metallic compounds.
Radiochemistry treats of radioactive substances.
Photochemistry treats of chemical changes taking place in photographic processes.

PHYSIOGRAPHY, sometimes called *Physical Geography*, treats of the physical features of the earth's surface. It is subdivided into *Geology* and *Geography*.

GEOLOGY, science of the past and present condition of the earth. Further subdivided into:
Astronomical Geology treats of the earth as a planet.
Historical Geology, study of chronological succession in development of rock forms and of organisms.
Stratigraphy treats of the order and position of the stratified groups.
Paleontological Geology treats of the life of former geological periods.
Physical Geology, study of geological changes in the earth's surface.
Structural Geology treats of the position of materials in the earth's crust.
Petrology, the study of rocks.
Mineralogy, the study of minerals.
Crystallography, the study of different forms of crystals.
Economic Geology treats of geological relations of useful minerals, rocks and ores.
Agricultural Geology treats of soils, subsoils, subjacent strata and mineral manures.

Dynamic Geology treats of the causes of geological changes.
Lithology deals with the composition, structure and history of the earth's rocky shell.
Seismology, the science of earth disturbances.
GEOGRAPHY, science of the present earth's surface and things on it. Further subdivided into:
Hydrology treats of the oceans, lakes, ponds and rivers.
Oceanography, that branch of hydrology which treats of the ocean.
Commercial Geography treats of commerce, location of commodities, local conditions, routes of trade, etc.
Political Geography treats of the present division of the earth's surface among different governments.
Historical Geography treats of the past division of the earth's surface among different governments.
Biblical Geography treats of countries mentioned in the Bible.
Meteorology, the scientific study of weather and climate, their causes, changes, relations and effects.
Atmology. A better name for meteorology.

KNOWLEDGE OF MATTER, ENERGY AND LIFE. Sometimes called *Biology* and together with Knowledge of Matter and Energy sometimes called *Natural Science*. It includes Botany, Zoology and Anatomy.

BOTANY: The science of plants. Further subdivided into:

Morphological Botany treats of the structure of plants.
Histological Botany treats of the structure and tissues of plants.
Cytology deals with the structure, development and functions of the cell.
Embryology deals with the development of plant cells.
Physiological Botany treats of the history and functions of plants.
Phytopathology treats of plant diseases.
Ecology treats of environmental influences on plants.
Phytogeography treats of the distribution of plants.
Taxonomy treats of classification of plants.
Economic Botany includes Agriculture, Forestry, Horticulture, etc.
Paleobotany treats of fossil plants.
Descriptive Botany treats of description and nomenclature of plants.
Medical Botany treats of plants used as medicines.

ZOOLOGY: The science of animals. Further subdivided into:

Metazoology, the science of metazoa or many-celled animals.
Mammalogy, science of mammals.
Ornithology, science of birds.
Herpetology, science of reptiles.
Ichthyology, science of fishes and lower aquatic vertebrates.
Conchology, science of molluscs.
Crustaceology, science of crustaceans.
Entomology, science of insects.
Arachnology, science of spiders, scorpions, etc.
Helminthology, science of worms.
Echinology, science of sea urchins, etc.
Zoophytology, science of Zoophytes.
Spongology, science of sponges, etc.
Protozoology, science of protozoa or single-celled animals.
Systematic Zoology considers animals in morphological relations to each other.
Paleozoology, study of the life of former geologic periods.
Paleontology. Another name for paleozoology.

ANATOMY: Science of the bodily structure of animals and plants. Allied subjects:

Physiology treats of the functions of living things.
Hygiene treats of principles of promoting health.
Histology treats of the microscopic structure of body tissues.
Embryology treats of the development of embryos.
Morphology treats of form and structure of plants and animals.
Medicine treats of organic and inorganic substances and their action on body tissues.
Osteology treats of the bones of the body.
Surgery, the application of the knife and the principles of anatomy in the treatment of injuries.

KNOWLEDGE OF MANKIND subdivided into Knowledge of Physical Man, Knowledge of Mind and Knowledge of Society. *Knowledge of Physical Man* covers Anthropology. *Knowledge of Mind* is subdivided into Philosophy, Logic and History. *Knowledge of Society* is subdivided into Ethnology, Political Economy and Philology.

ANTHROPOLOGY: The science of the physical structure of man. Further subdivided into:

Physical Anthropology, the natural history of man.
Ontageny treats of the embryo and the life of the individual.
Anatomy treats of the body specifically and comparatively.
Physiology treats of the functions of the body.
Anthropometry treats of the form, color, weight, etc., of the body.
Psychology treats of the nervous system in relation to thought and feeling. See Philosophy.
Ethnology treats of the natural divisions of mankind.
Cultural Anthropology treats of what man does artificially.
Glossology treats of expressing thoughts.
Technology treats of supplying wants.
Esthetology treats of giving pleasure.
Sociology treats of cooperating in life's ends. See under Ethnology.

PHILOSOPHY: Variously defined as: The body of highest truth; the organized sum of science; the science of which all others are branches; the science of the most fundamental matters. Further subdivided into:

Metaphysics, the philosophy of the real, or the science of the inward and essential nature of things.
Epistemology, the theory of knowledge.
Ontology, the theory of reality.
Psychology, the science of the phenomena of mind.
Materialism, the philosophy of the material.
Idealology the philosphy of the ideal.
Ethics, the science of right conduct and character.
Aesthetics, the philosophy of the beautiful, leading to art and literature.

LOGIC: The science of the distinction of true from false reasoning, with whatever is naturally treated in connection therewith. Further subdivided into:

Methodology shows how the abstract principles of logic are to be applied to the production of knowledge; the science of method in scientific procedures.

Abstract Logic, the general theory of logic.

Concrete Logic, logic as an element of active thought in the prosecution of science.

Formal Logic, the principles and methods of deductive reasoning.

Symbolic Logic, formal logic expressed by mathematical symbols.

Several other kinds are recognized.

HISTORY: The narrative, oral or written, of past events, with the ascertaining and recording thereof. Further subdivided into:

Ancient History, the history of man from earliest authentic records to the destruction of the Roman Empire.

Classical History, the history of the Greeks and Romans.

Medieval History, the history of the middle ages, from A. D. 476 to about A. D. 1517.

Modern History, the history of the period from about 1517 to the present time.

Sacred History, the history recorded in the Bible.

Profane History, the history of secular events as distinguished from Sacred History.

Ecclesiastical History, the history of the Church from the beginning to the present time, including both Old and New Testament history.

Natural History, the study and description of animals, plants and minerals; also geology.

Archaeology, the science of antiquities.

Classical Archaeology relates to Greece and Rome.

Medieval Archaeology relates to the middle ages.

ETHNOLOGY: The science of the races of men, and of their character, history, customs and institutions. Further subdivided into:

Sociology treats of the general structure of society, the laws of its development, the progress of civilization and all that relates to society.

Ethnography deals with the description and classification of races of men.

Political Science treats of politics, and of government and its relation to public and private affairs.

Law, a system or collection of rules of action, prescribed by authority of a sovereign or of a state, and binding upon men.

Government, the authoritative direction and restraint exercised over the actions of men in communities, societies or states; also the governing body exercising this authority.

Mythology, the science of myths and their interpretations with reference to peoples and their beliefs in gods.

POLITICAL ECONOMY: The science of the laws and conditions regulating the production, distribution and consumption of all products needed or used by man.

Economics. See Political Economy.

PHILOLOGY: The study of languages and their literatures for the light they throw on men's character, activity and history. Further subdivided into:

Comparative Philology, a comparative study of human languages and of the origin and history of words.

Linguistics. See Comparative Philology.

Oriental Philology, a study of Hebrew, Sanskrit and other Oriental languages as keys to their literatures.

Classical Philology, a study of language in connection with history or literature.

Modern Philology, a study of present day languages as keys to their literatures.

Grammar, a systematic account of the usages of a language, its parts of speech, inflections and formation of sentences.

Orthography, the art of spelling and writing words.

Etymology, treats of the derivation, history, classification and inflection of words.

Syntax deals with the sentence and the relations existing between the parts of which it is composed.

Phonetics deals with the pronunciation of letters and words.

Rhetoric deals with the use of language in speaking.

Paleography, the science of deciphering ancient documents.

APPLIED SCIENCE: The main chart is followed by a section on Applied Science with reference to the application of the pure sciences and with a list of the different kinds of engineering as follows:

APPLIED SCIENCE, sometimes called *Practical Science*, sometimes *Lucrative Science*, includes any of the *pure* sciences when applied to the industries as distinguished from their study as abstract or theoretical sciences. Nearly all science can be *applied*, but *engineering* is strictly applied science.

ENGINEERING: The art of making, building, and using engines and machines, or of executing civil or military works requiring a knowledge of the laws of mechanics.

Civil Engineering relates to the construction of roads, bridges, railroads, canals, harbors, aqueducts, steel frames for buildings, etc.

Structural Engineering. See Civil Engineering.

Architectural Engineering. Civil Engineering as applied to buildings.

Military Engineering relates to the construction and maintenance of fortifications and other war buildings and accessories.

Naval Engineering relates to the building and operation of ships and naval accessories.

Marine Engineering. See Naval Engineering.

Topographical Engineering relates to the surveying of land for ascertaining and recording variations in level and contour, etc.

Mining Engineering relates to selecting, testing, opening, and working mines.

Agricultural Engineering relates to the operation of large scale farms and the necessary accessories.

Sanitary Engineering relates to the structures and operations for promoting and guarding the health of communities.

Municipal Engineering. See Sanitary Engineering.

Chemical Engineering relates to the design, construction and operation of chemical plants and the manipulation of chemical processes.

Metallurgical Engineering relates to the design, construction and operation of plants extracting metals from ores.

Illuminating Engineering relates to the installation and operation of lighting systems.

Mechanical Engineering relates to the design, construction and operation of machines.

Hydraulic Engineering relates to the construction of water-works and hydraulic machinery, the improvement of waterways, etc.

Steam Engineering relates to the design, construction and operation of steam engines and accessories.

Dynamic Engineering relates to the generation and transmission of power.

Heating Engineering relates to the installation and operation of heating systems.

Aeronautical Engineering relates to the design, construction and operation of heavier-than-air and lighter-than-air machines.

Electrical Engineering relates to the production, transmission and use of electricity in producing light, heat and power and in metallurgical processes.

Radio Engineering relates to the design, construction and operation of radio plants.

TANGENT LINES AMONG THE GREEKS.

By G. A. Miller,

University of Illinois, Urbana, Ill.

Judging from Professor Cajori's article under the above heading, published on page 463 of this volume, it seems that I did not make it sufficiently clear why I regarded the following statement as not reasonably accurate: Roberval "broke off from the ancient definition of a tangent as a straight line having only one point in common with a curve." The inaccuracy of this statement appeared to me to be so obvious that a hint would be sufficient even for those who know only a little about the history of Greek mathematics. From the article noted above it appears that this hint was insufficient even for a professional mathematical historian and hence it may be desirable to furnish here some additional data in support of my conclusion.

On page 57 of the well-known *Aperfu historique des méthodes en géométrié* by M. Charles, second edition, 1875, one finds the following sentence: "The ancient geometers defined the tangent to a curve as a line which, having a point in common with the curve is such that one cannot draw through this point any other line between this one and the curve." In the definition quoted in the preceding paragraph the latter part of the definition just noted is omitted. By this omission the definition becomes inaccurate not only for the student of today, but it also fails to exhibit a very fertile field of Greek speculation relating to the angle of contact, or the horn-like angle, which is an instance where Greek geometers met with a magnitude which does not obey the so-called Archimedean postulate and hence is of unusual historic interest.[1]

[1] Cf. *Encyclopédie des Sciences Mathématiques*, tome 3, vol. 1, p. 136.

We refer to this interest because one might expect that as regards such points a writer on the history of mathematics would be especially careful and explicit. At any rate, the beginner in this history cannot afford to have vague notions as regards such fundamental matters. When such a reader recalls that according to the Greek view a diameter of a parabola has only one point in common with this curve, and remembers that the Greeks knew that a tangent to the parabola is parallel to the chords which are bisected by the diameter meeting the curve at the point of tangency, he cannot fail to see that the Greeks could not have thought that a straight line, which has only one point in common with a curve was necessarily a tangent line. They certainly did not regard the diameters of a parabola as tangents of this curve.

It is also certain that the Greeks confined themselves to the consideration of *real points* on a curve, and that they studied curves, such as the cissoid, which have the property that one can draw an infinite number of straight lines through any ordinary point of the curve such that none of these lines is a tangent line and each of them meets the curve in only one real point. Moreover, it is well-known that Archimedes studied the tangents of the spiral known by his name and that such tangent lines cut the spiral in an infinite number of real points.

In view of the well-known facts mentioned above one reads with some astonishment in the article noted in the opening sentence that "what we do know is that the Greeks constructed tangents to circles, to conic sections and to certain other curves having no singular points. For these curves the point of view stated in my history is necessary and sufficient." From the diameters to the parabola it follows directly that this condition, as stated in the first paragraph of the present article, is not sufficient, and from the tangents to the spiral of Archimedes it results that it is also not necessary. Hence the sentence just quoted should be modified so as to read that this condition is neither necessary nor sufficient. It appears to the present writer that this is a somewhat substantial modification in the interest of accuracy.

On page 58 of the work mentioned at the opening of the second paragraph M. Chasles noted that the ancient definition of a tangent to a curve was not sufficiently fertile and hence the more modern geometers took a different view of the tangent lines. They regarded them as secant lines when two points of intersection become coincident, or as the prolongations of infi-

nitely short sides of a curve considered as a polygon having an infinite number of sides. They also regarded them as the direction of composite movements by which the curve can be described.

In view of the fact that the method of stating the case by the present writer was somewhat severely criticized in the article noted in the opening sentence, it may be desirable to add that the present writer believes in a history of mathematics which aims primarily to establish conjectures by arguments. To him the mere recording of facts is a much less attractive feature of the history of mathematics than the collection of evidence tending to establish a view of fundamental importance. In other words, he admires a well reasoned conclusion relating to a historical question. In particular, he regards it entirely legitimate to ask the question what kind of a definition of a tangent line might one expect from the Greeks in view of their other geometrical attainments.

If a definition, like the one quoted in the opening paragraph, seems entirely unworthy of the better Greek mathematicians, he is naturally inclined to reject it unless it is proved to him that these mathematicians actually used such a definition. His great admiration of the mathematical achievements of the ancient Greeks does not permit him to do otherwise. It is true that many of the ancients made ridiculous mathematical errors and that some modern writers do not permit the ancients to excel them in this particular, but this makes it all the more desirable to give credit where credit is due.

PRODUCTION OF FULLER'S EARTH IN 1921.

The output of fuller's earth in the United States in 1921 was 105,609 short tons, valued at $1,973,848, according to the United States Geological Survey, Department of the Interior. The quantity decreased eighteen per cent and the value twenty-one per cent as compared with 1920. In 1921 the average value per ton at the mine was $18.69; in 1920 it was $19.51. Fuller's earth is found in many states, but in 1921 it was mined only in Alabama, Arkansas, Florida, Georgia, Massachusetts, and Texas. Florida has been the leading state in production ever since the industry was established in this country, in 1895, and in 1921 it made fifty-four per cent of the total output. Georgia and Texas were second and third, respectively, in output and value.

The imports of Fuller's earth in 1921 were 9,744 short tons, valued at $119,415, a decrease of forty-nine per cent in quantity and forty-six per cent in value as compared with 1920, and the lowest quantity since 1900, and only a little more than a third of the maximum, which is credited to 1914. The average value per ton of imported earth at the principal markets of the country from which it was exported was $12.26 in 1921 as compared with $11.54 in 1920.

THE METHODS AND AIMS OF MATHEMATICAL SCIENCE.

By Louis C. Karpinski,

University of Michigan, Ann Arbor, Mich.

Mathematics is the oldest recognized school discipline. While this may not commend the subject, particularly to those who are being disciplined thereby, yet the fact has profound historical significance. If the names and the political methods of ten thousand nominal rulers of Egypt and Babylon and Greece have been considered significant in the intellectual consideration of the history of mankind, how much more significant is a study which gives us some conception of ancient ways of thinking; how much more significant a study which gives us actual material with which the ancients occupied themselves.

From the earliest times mathematics has been studied not only for its practical value but also as a mental discipline. Among the Greeks Pythogoras is given credit for considering arithmetic from the philosophical point of view, aside from any application. Fortunately for the practical the intellectual treatment dominated the study of mathematics throughout its period of most rapid development.

For students in an American University mathematics should be considered from the point of view of comprehending the world in which we live. The world of today is the world of the scientist, the world of the engineer and the mechanic; it is the world of the chemist, the physicist, the biologist, and the physician-scientist; it is equally the world of the astronomer, of the artist, and of the thinker. Man is distinguished from other living creatures by his powers of reasoning; the world in which he lives is a world of thought and of people who think. Mathematics is an essential industry in any such conception of the world of today.

Consider for a moment the function of mathematics in the work of the engineer. All students, all who take any pride in being intelligent about our universe, should know something about the problems and difficulties of engineering, the fundamental and basic ideas upon which the great superstructure of modern engineering is erected. Society requires that we live in harmony; this demands an intellectual appreciation each of the the other's work.

[1]A lecture delivered in a course of lectures given to freshmen at the University of Michigan, for the purpose of acquainting the freshman with the fundamental notions of various departments of knowledge.

If you seek a monument to mathematics, look around. In every auditorium, in practically every large theatre, an algebraic equation, $y^2=4ax$, and a related geometric curve, the parabola, are at the very foundation of the construction of the hall. In the Hill Auditorium at Ann Arbor, a hall seating more than 5,000 people, the simple equation $y^2=70.02x$, determines the form of the walls, determines the length of the stage, determines the height of the ceiling. Not any love for the mystical determines this relationship but rather it is determined by the geometrical properties of this curve combined with the physical property of sound waves that they are transmitted in straight lines and reflected like rays of light.

In the building of a bridge, such as the recent tremendous 1,000-foot arch in New York City, over Hell Gate, or such as the Alexander III bridge in Paris, beauty is almost as fundamental a consideration in the eye of the architect as safety and usuability. Here, too, it is found that this same parabola, a curve which can be cut from a circular cone, fulfills the mechanical requirements and at the same time offers satisfaction to the eye. Possibly you are so constructed that a great and beautiful bridge as a reflection of a simple algebraical equation and as a reflection of a simple geometrical curve offers you no intellectual satisfaction; however, that is a limitation similar to the lack of appreciation of poetry or music or of other harmony and beauty in the universe. The bullet in its flight approximates the same curve; the suspension bridge presents the same; the automobile headlight is built upon the same model; so is the new roadway over the Huron river, near Ann Arbor, and many another roadway.

Arithmetic and algebra, trigonometry and geometry, and analytical geometry are all involved in the construction of such a bridge, in the construction of such a hall. For the engineer it is evident, then, that the mathematics is a tool which he must learn to use even as he uses T-square and compass and triangle.

Quite as dependent upon mathematics as engineering is modern commerce and industry. Of course the factory has the mathematical problems of the engineer; but the office and the administration has equally mathematical problems even more subtle, involving frequently the apparently uncertain human element.

The binominal theorem, illustrated on next page, appears at first sight as a perfectly harmless amusement for children, or for the academic youth, let us say. However, in

$$(a+b)^2=a^2+2ab+b^2,$$
$$(a+b)^3=a^3+3a^2b+3ab^2+b^3,$$
$$(a+b)^4=a^4+4a^3b+\frac{4\cdot 2}{1\cdot 2}a^2b^2+\quad .\quad .\quad .,$$

the hands of the economist this is a dangerous weapon, or, at least, a powerful one. The price of a bond depends upon this theorem; the actual cost of any instrument which depreciates with use depends upon this mathematical formula. Yes, the sufficiency of a nickel for a street-car fare may hinge upon the binomial theorem; the 2c or 3c a mile for a railroad fare depends upon it; even the price of a sandwich or a pair of shoes involves the same formula. Replacement and insurance, life insurance and health insurance and fire insurance are all founded and grounded upon a mathematical substructure. If you have any suspicion that your abilities lie in business administration, get acquainted with the binomial theorem. You will need it in your business.

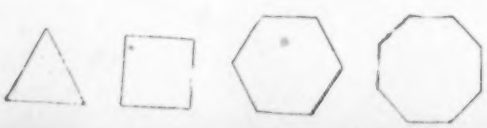
But these illustrations are drawn particularly from our material interests. The astronomer handles problems which are more remote so far as our bread and butter needs are concerned. The astronomer will tell you that you are even now moving upon an ellipse, the path of the earth about the sun being an ellipse, $x^2/a^2+y^2/b^2=1$, with the sun not at the center of the path but some 1,500,000 miles off center at the focus of the ellipse. So the other planets move in elliptical orbits about the sun. Probably the power of mathematics has never been shown more vividly than by two astronomers working independently who calculated a planet into existence. Astronomers had noted certain irregularities in the motion of one of the planets. By a study of these perturbations or disturbances, Adams, an Englishman, and Leverrier, a Frenchman, computed that these disturbances must be caused by an unknown planet whose orbit they were able to determine. Then when this planet again came within the range of the telescopes Adams instructed certain astronomers to turn their telescopes to a certain spot in the heavens where the new planet actually was found—Neptune.

The beauty of mathematics is found, for the mathematically inclined, at least, in the contemplation, for example, of series of numbers:

1, 3, 5, 7, 9, 11, 13, . . . $.2n-1$.

1, 4, 9, 16, 25, 36, 49, ... n^2.

or in form:



The question which the mathematician asks when confronted with such a series is:

"Are there any more at home like you?" The discovery of the pentagon, the five sided regular polygon as a possible construction with ruler and compass, marked the beginning of a new period in mathematics, really logical geometry. Following this the cosmic solids were constructed.

The five cosmic solids are the tetrahedron, cube, octahedron, dodecahedron, and icosahedron. There are only five of these regular solids possible in our universe of three dimensions.

The mathematician builds up a system of geometry, each proposition more or less following upon the preceding. This is an intellectual problem, primarily; it is occasioned, however, by the world in which a thinking being finds himself.

Just as geometrical forms present themselves to reflective beings so also a first degree equation presents itself. To the Egyptian as $x+x/7=19$, the number which when its seventh is added gives 19. Then pure quadratics and cubic equations followed much later. The solution of the quadratic came by geometrical methods quite early to the Greeks; the analytical solution was obtained much later by the Arabs and Hindus.

Here the astonishing fact is found that these two diveser routes of number and form lead to a consideration of fundamentally related problems. The problem solvable by quadratics corresponds to a geometric problem solvable with ruler and compass. The Greeks solved geometrically; the Hindus and the earlier Egyptians solved numerically. The Arabs combined the two. But this wonderful connection between geometry and algebra was not fully exploited until Descartes in the seventeenth century, 1637, invented or rather discovered the analytical geometry. Here the straight line is represented by a linear or first-degree equation; the circle by a quadratic equation of simple type; $x^2+y^2=100$; the parabola, ellipse, and hyperbola by other simple quadratics.

Another step in this direction of discovering fundamental unity was made with the discovery at the end of the eighteenth century of the analytical representation of complex numbers, by a Dane, Caspar Wessel. The connection then was shown between these geometrical figures, regular polygons inscribable in a circle, and the equations of type

$$x^5=1;\ x^4=1.$$

Now a mechanical mathematical genuis like the great electrician

Steinmetz finds these imaginary numbers very convenient in his business furthering the development of electricity, scientific and practical. Similarly mathematical considerations of a theoretical type led up to the present wireless telegraph and telephone.

The imaginary may suggest to some of you the fourth dimension which is frequently given as an illustration of mathematical nonsense. Of course much nonsense has been written in this topic, *but not by mathematicians.* Spiritualists have had the nerve to locate the spirits in the fourth dimensions, and domesticated them to rap on tables, tip over chairs, or perform other useful tasks. For the mathematician, of course, the fourth dimension exists no more and no less than the fifth or the first, or than the third, to which the world of sense corresponds. A line is real to the mathematician, but real only in thought; this line on the blackboard is solid, actually solid; you can measure it; you can weight it. A plane is also a solid as soon as you can touch, taste, or handle it; it is a plane only in thought.

In conclusion, I wish to discuss the method of work of mathematicians because it is the method of work, of creative thought in every field of human endeavor, whether of music or art or literature or mathematics. None of you students here may ever develop into creative mathematicians; there would be no occasion for surprise if that were true; however, Michigan may well expect that a number of you may develop into creative workers in literature, in engineering, in medicine, in intellectual work of one kind or another. All of you who profit by a college education should be compelled somewhere and somehow to think deeply and consecutively, consistently, in some field of human endeavor.

An inquiry was made some years ago into the method of work of mathematicians. Such men as Poincaré responded. Poincaré mentioned that the idea for his first real contribution to mathematicis came to him as he put his foot on the step of an omnibus while engaged in his period of two weeks' military service. Again and again men have reported that creative ideas came to them suddenly in the night, or at some time when apparently not actively working on the particular subject. However, no man has ever reported that any idea came to him in a field in which he had not previously and even recently been working. No mathematician has reported that the ideas came fully elaborated. Work, work, work; that has been and ever will be the absolutely essential condition for creative thinking along any line which is worthwhile for human bengs.

THE RÔLE OF MEMORY IN ALGEBRA

By Charles H. Butler,
University of Chicago.

(Continued from page 613, October, 1922.)

Chapter III—Memory Factors in Algebra.

Introduction.

In the foregoing chapters the reader has been introduced to the fundamental elements and characteristic types of thought involved in algebra, and to the different types of memory. The present chapter is an attempt to correlate the substance of the previous discussion in an effort to discover the extent to which memory functions in algebraic thinking, to the end that it may be profitably suggestive in the formulation of a teaching and supervisory technique. We shall take up first the broad application of memory, in general, to the elements of algebra, following this with a discussion relating to the specific types of memory to particular thought processes which are involved in algebra. The second part of the chapter will suggest the ways in which a consideration of this application may modify and make more effective the teaching and supervision of the subject.

Correlation of Types of Memory with Types of Algebraic Thinking.

Broadly speaking, algebra is essentially a subject requiring rational thought processes, and rational thought cannot be carried on without the recall of previous experiences. It is very clear, then, that memory, in some form, must be a factor in all algebraic thought. In considering what kind of memory functions to best advantage we may very properly return to our discussion of the two different attitudes assumed by educators toward the subject. It will be remembered that the apparent disparity of the views lies in the lack of a common definition; that in speaking of *memory*, two different ideas were in the minds of the opposing groups. A jumble of unassimilated facts is undesirable in any subject, but an organized coherent classification of ideas is indispensable to the pursuit of algebra, just as it is indispensable to the study of any subject.

Algebra involves analysis and the use of symbolism. Analysis depends not only upon previous experience, but also upon the recall of that experience. The skilled tennis player may return a service with a "Lawford" stroke, but unless he is a very keen analyst he cannot teach another how to do it, and unless he can recall the coördinations of movement he cannot analyze his

stroke. In the same way, the analysis of an algebraic situation requires retention and recall.

Synthetic thought is certainly a very vital element in algebraic solutions, and involves retention and recall even to a greater extent than does analysis. In synthesis there is a possibility of effective use of specific types of memory falling under any of the three chief divisons in the classiffcation given in Chapter II: (1) rational types, (2) arbitrary types, and (3) miscellaneous types. Synthesis rests upon a definiteness of aim which cannot be consummated without a comprehensive recall and review of the different things from which must be chosen those which best fit into and contribute to the complement of the scheme. The wide range of types of recall which may be effective furnishes additional evidence of the comprehensive nature of the memory involved. It is a recall not of one particular thing, but of all elements which have been revealed by analysis, and which may possibly help in the solution.

Furthermore, the interpretation of the symbolism used in algebraic operation, and the manipulation of this symbolism are as absolutely dependent upon recall as the interpretation and use of words is dependent upon familiarity with the language. There can be no question, then, of the proposition that memory of the right sort is, in general, requisite to algebraic ability.

Memory In Abstraction.

In our discussion of the *psychology of abstraction* it was pointed out that this process, which is the foundation of algebraic thought, requires that the attention be focused upon one phase or aspect of a situation to the exclusion of all others; that this aspect be isolated from the other associations to which it has been customarily related, but which, for the purposes of abstraction, are irrelevant, and distracting. In this connection recall and retention have an important part to play. In order that one idea may predominate throughout the process, conscious attention will have to be given, in order that other aspects may not creep in, unobserved, and that the germ idea may not slip away. This is particularly true in the case of students just learning to form abstractions. The pertinent aspect must be recognized to be consciously kept in mind, while others must be recognized *in order that they may be disregarded.* The discrimination is not possible unless there is recall. Concentration and sheer retention are indispensable

to the process of abstraction. The sort of memory involved is a *volitional* recall. With mature students this may merge into an habitual reaction to situations as they are presented.

We have seen also that words and symbols are the chief instruments of abstraction and that the effective use of these is wholly dependent upon the recall of their interpretations and applications. Sheer recall will again function here in the initial attempts to make use of these instruments, but it is only through habituation of the recall that they can be utilized to the best advantage.

Memory In Relation To Specific Types Of Algebraic Thought.

In the first chapter of this paper we set forth several specific types of thought processes which are involved in the study of algebra. Similarly, in the second chapter we identified a number of particular types of memory. In view of the aim of this paper, it seems appropriate at this point to bring these two elements together, and to discover what correlation exists

Table I.

Specific Types Of Memory / Specific Types Of Thought In Algebra	Sheer recall	Reflective Recall	Rational-Assoc. Recall	Habitual Recall	Algoristic Recall	Conceptual Recall	Sensory Recall	Mnemonic Recall	Parrot-like Verbal Recall	Freakish Recall (Idiosyncracies)	Photographic Memory	Encyclopedic Memory	Comprehensive
Conceptual	□	□	□		△	□							△
Expressional	△	△	△	△	□	□	△	△					
Associational	□	□	□	△		□		△					
Assimilation	△	□	□			△	△	△		△	△	△	△
Generalization	□	□	□	△		□				△		△	△
Reasoning	□	□	□			□							△
Drill	△			□	□		△	□	△	△			
Review	□	□	□			△		□		△	△	△	△
Test	□	□	□			△		△		△		△	△
Routine	△			□	□		△	□					
Application	□	□	□	△		□		□		△			△
Research	□	□	□	△	□	□				△		△	□
Appreciation	△	□	□	□	□	□	△	△		△	△	△	□

between them. This might be done by taking each type of thought independently and discussing it in connection with each of the types of memory; or each type of memory might be taken up in turn, and the different types of thought examined in order to determine in which ones the various memory types find application. For two reasons, however, neither of these methods will be followed. In the first place, the quantitative limitations of this discussion preclude the prolixity which would be inevitable in either case. In the second place, each type of thought and each type of memory has been discussed already, and either of the methods we have mentioned would necessitate a large amount of repetition. We shall resort to tabulation, then, and reserve our comment for the inferences which may be drawn from the tabulated findings.

The table I is an attempt to show the correlation between algebraic thought and memory types. The spaces which are marked with squares represent close correlations which are almost certain to exist; those marked with triangles indicate only a probable correlation. It should be borne in mind that the correlations indicated are but the result of a *subjective* analysis. There is no way of objectifying it, but this will not save it from criticism on this score. The reader is urged to examine it carefully, keeping in mind its subjective nature, and after a thorough perusal, to make such modification of it as may seem to him justified.

TABLE II.

	Mem Types				Mem Types				Mem Types		
Thought Types	Strong Correl-	Probable Correl-	Total Correl-	Thought Types	Strong Correl-	Probable Correl-	Total Correl-	Thought Types	Strong Correl-	Probable Correl-	Total Correl-
Conceptual	3	4	7	Generaliz-	3	4	7	Test	2	5	7
Expressional	2	5	7	Reasoning	3	1	4	Routine	3	2	5
Association-	3	2	5	Drill	3	4	7	Application	4	3	7
Assimilation-	1	8	9	Review	3	5	8	Research	4	4	8
								Appreciation	4	6	10

An examination of Table I shows that all the types of thinking involve several of the memory types, the strong correlations predominating in some cases, and the possible or weak ones in others. This data is collected and compiled in Table II.

This table shows that there is not one of the thought types which does not involve almost certainly *one or more* of the types of memory, while most of them show a distinctly greater number of strong correlations and a still larger number of probable correlations. On the average, a single type of thinking *almost certainly involves three* types of recall and *probably involves four others.*

Table I furthermore reveals the fact that certain types of memory are found in algebra, while certain other types find relatively little application. For example *sheer recall* is found in all the types of thought, *conceptual recall, reflective, and rational-associational* recall in all but two, while mere repetitive verbal recall is involved in only one. These correlations are shown in Table III.

TABLE III.

	Thought Types				Thought Types		
Memory Types	Strong Cor-	Probable Cor-	Total Cor-	Memory Types	Strong Cor-	Probable Cor-	Total Cor-
Sheer Recall	8	5	13	Conceptual Recall	8	3	11
Reflective Recall	10	1	11	Sensory Recall		5	5
Rational-As. Recall	10	1	11	Mnemonic Recall	4	5	9
Habitual Recall	3	5	8	Verbal Recall		1	1
Algoristic Recall	3	2	5	Freakish Recall		9	9
Comprehensive Recall	2	7	9	Photographic Recall		3	3
				Encyclopedic Recall		7	7

This table should be read as follows: Sheer recall is a certain and important factor in eight of the thought types, and is probably involved in 5 others, thus giving it a possible application in 13 of the types into which algebraic thinking has been separated. Examination shows that certain of the memory types appear to be of much more importance than others. For

example, *sheer recall* finds 13 applications, *reflective*, *rational-associational*, and *conceptual* recall eleven each, and so on down the list to a type which finds only one possible application. This difference is further emphasized by considering that only 4 memory types have 8 or more definite correlations each, while 4 of them have only from 2 to 4 such applications, and the remaining 5 have none at all.

We may now profitably confine our attention to those types of memory which find specific and definite application to algebraic thought. Table III shows that there are 8 of these. Two of this number (*reflective*, and *rational-associational* recall) are identical *in their application* and we shall reduce the number to 7 by considering them as one. Reference to Table I shows that every type of thought process made use of in algebra definitely involves some form of memory to a greater or less degree. From an aggregation of the table we find that in 91 possibilities of application there are 38 actual definite correlations. This would seem to establish beyond question the importance of the memory factor in the study and teaching of algebra.

The matter of the particular application of the different types of recall to the great variety of algebraic situations is a problem for the teacher and the supervisor. We shall endeavor, in the following sections of this discussion, to discover the effect of a consideration of the application of memory to algebraic thought processes in the formulation of a teaching technique and a supervisory program or policy.

(To be concluded.)

A COMPOSITE COURSE FOR SEVENTH AND EIGHTH GRADE MATHEMATICS.

By M. J. Newell,

High School, Evanston, Ill.

A report by the Articulation Committee for Mathematics of the Lake Shore Division of the Illinois Teachers' Association.

Foreword. The territory of the Lake Shore Division of the Illinois Teachers' Association comprises some half dozen counties in the northeast corner of the state exclusive of the city of Chicago. A considerable portion of its population is suburban to the larger city and practically all of its business activities center there. Its educational experiences and problems are not peculiarly its own for all of its communities are vitally Ameri-

can. It does admit a large foreign element in its population but this is well distributed and eagerly striving to become American. But its compact territory, good transportation, and alert school authorities have all served to keep it well forward in striving for the solution of educational problems.

Organization of Township High Schools. With one or two exceptions[7] all the secondary schools within a radius of seventy-five miles of the city of Chicago are organized under the Township High School Act. This plan of organization is very popular in Illinois with nearly four hundred such districts already in existence and the number increasing everywhere through the state with the coming of paved roads.

Drawbacks of Township High School. But the township high school tends greatly to magnify the differences in organization, and especially, in methods of instruction that exists everywhere in this country between the elementary school and the secondary school.

(1) The elementary school and the township high school are under distinct school boards, with distinct and absolutely independent teaching forces and superintendents. The high school is not responsible to the elementary school nor is the elementary school in any legal way responsible to the high school.

(2) The township, which is the high school district, usually includes several independent elementary school districts, each with its own school board, its own independent superintendent, and its own methods of meeting educational problems. If one elementary district in a given township has a reasonable population and considerable wealth, it cannot help but work out its problems in a better manner than its neighbor district in the same township, with larger population and less wealth. But under the Township High School Act the secondary school must accept the diplomas from every grade school in its territory and at their face value.

Efforts to Meet Drawbacks. To bring about a better co-ordination between the grades and the high school, many township principals have adopted the plan of making some instructor who is well-known and popular throughout the high school district chief liaisson officer—his duty being to visit all the teachers of the higher elementary grades in their classrooms, study their difficulties at first hand, and present the problem of deficiency in preparation for the upper school. Of course this can only be done with the full approval and consent of the grade superintendent.

Some high schools, ruled out of direct contact with the grade teachers, have aroused their interest and zeal by following the college plan and sending back to each the record of the work in the upper school made by each graduate of the lower during his first semester.

One township high school of the Lake Shore Association has an Articulation Committee appointed from its faculty, one representative for each freshman subject, that meets all the seventh and eighth grade teachers at the high school building several times during the school year. These meetings have served to bring about a fine spirit of cooperation between the teachers of the six elementary school districts that comprise the township and the high school. Minimum requirements have been agreed upon for the important grade subjects, notably English and mathematics. Some of the common errors made in the upper school have been listed and some study made of their causes. This particular school has this year, for the first time, attempted to classify all first year students on the basis of the Otis Tests given last spring in the grades, together with the records of the grade teachers and their estimates of ability. It has placed all slower pupils in distinct sections so as to enable them to proceed at their own speed. The reports from such grading should prove interesting.

Such a committee should get on with the problems of students' errors and what should be the carry-over from grades to high school.

Elementary Schools Awake. The elementary school authorities are fully abreast of the problem of better preparation. Each year an increasingly larger per cent of their graduates enter the upper school. Of forty-five who received diplomas from one grade school in June, 1921, forty-three enrolled at the local high school in September. A similar record will be found in many other communities. Professional pride requires that the standard of preparation shall be as high as possible.

Growth of Departmentalized Grade Schools. In northeastern Illinois there has been a steady growth in the number of departmentalized seventh and eighth grade schools[6]. The Township High School Act, which restricts the district thus organized to the control of ninth, tenth, eleventh, and twelfth grades only, is apparently compelling the adoption of the 6-2-4 plan. Such two-year schools are to all intents Junior High School of two grades. Several new buildings and remodeled old buildings have been entirely given over to the use of such schools. In a

large number of elementary districts the seventh and eighth grade pupils have been assembled from several contiguous wards in suitable rooms of a single convenient building. In smaller elementary districts, that have but a single building, the problem of departmentalizing these grades has been easier. In every district able to pay the bill two or three years will see the reorganization completely worked out. But of course the problem of teacher-preparation and of subject material will require a longer time. Whatever may be the actual advance in quality of preparation for high school due to this movement, at the present it is stirring the enthusiasm and arousing the professional spirit of the teachers.

They are striving to become specialists and are getting away to the summer schools of the universities in increasing numbers.

An Articulation Committee. At the annual meeting of the Lake Shore Association in April, 1921, the newly elected president, Principal E. V. Tubbs, of New Trier Township High School, named an Articulation Committee for mathematics consisting of ten grade and four high school teachers of the subject. The membership of this committee was selected with reference to a central meeting place and represents seven grade districts and four township high schools. To it was assigned the problem of better co-ordination. It is interesting to note that President Tubbs has recently named a similar committee for English.

At its first meeting in June the Mathematics Committee decided that its first duty was that of making a composite course that could be adopted with minimum changes throughout the Association. In the immediate suburbs of Chicago there is a constant movement of population and a considerable interchange of pupils during the year. The problem of adjustment to a new school is sufficiently difficult for the ordinary student even when the subject material is quite the same in the new and the old. But when the courses differ as widely as at present in some sections, the adjustment is impossible and a year is lost.

The Composite Course. The following is the composite course agreed upon by the committee. Few schools will need to make any very great change in their present material, time, or manner of its presentation. Furthermore, while not extreme or radical in any way, the committee believes that it holds close to the similar report of the National Committee on Mathematical Requirements.

Mathematical Topics for the Seventh Grade.

At the completion of the sixth grade the pupil should be able to perform the fundamental operations with integers, common fractions, and decimals with a fair degree of speed and accuracy.

I. Review briefly essential topics of previous grades for accuracy and against future needs.

II. Percentage and its applications.
1. Its three cases.
2. Change per cents to fractions and vice versa.
3. Choose problems:
   a. arising from the home and community,
   b. introducing industry and business,
   c. teaching thrift and economy.

III. Intuitive geometry and simple mensuration.
(All geometric terms to be carefully defined and correctly used.)
1. Construction work with compasses and straight edge.
   a. Drawing straight lines and circles.
   b. Bisecting line-segments and arcs.
   c. Constructing and measuring angles.
   d. Constructing perpendiculars.
   e. Constructing parallel lines.
   f. Reproducing and originating designs and patterns.
2. Constructing and using squares, rectangles, parallelograms, triangles, etc., measure lengths, compute areas, and derive the simpler formulas. (The formula as a shorthand.)

IV. Simple interest and its problems.
1. Introduce and use formula, $i = prt$.
2. Use business terms and methods.
3. Solve investment problems from real estate, postal savings, etc.

V. Graphs—their interpretation and construction.
1. Bar graphs.
2. Circle graphs.
3. Motivate 1 and 2 with simple problems requiring the expression in per cents or fractions of relative areas of given graphs.

Mathematical Topics for the Eighth Grade.

I. Review fundamental operations with integers, common fractions, and decimals for speed and accuracy.

II. Complete the study of percentage and interest.
1. Successive discounts and other business terms.
2. Banking and its papers.
   a. Savings bank interest.
   b. Bank discount.
3. Use problems:
   a. of investing money, loans, mortgages, stocks and bonds, etc.,
   b. teaching the terms and meaning of insurance,
   c. teaching the meaning and necessity of taxes,
   d. from internal revenue, tariffs, etc.

III. The Pythagorean Theorem and square root.
1. Explain the theorem by squares from cross section paper.
2. Teach method of square root and require reasonable accuracy.
3. Apply the theorem as widely as possible, diagonals, altitudes, etc.

Note.—Topics IV, V, and VI are to be taught in a unified manner.

IV. Mensuration.
1. Review work of seventh grade and construct regular polygons of 6, 8, and 12 sides.
2. Review and complete essential tables of denominate numbers.
3. Board measure and its formula.
4. Surface and volume.

Derive formulas for and apply to problems arising from, (a) trapezoid, (b) circle, (c) equilateral triangle, (d) prism, (e) cylinder, (f) cone, (g) pyramid, (h) sphere.

V. Simple equations.

1. Finding value of unknown.
2. Four operations performed on an equation.
3. Solving problems by equations.

VI. Formulas.

1. Evaluation of.
2. Changing subject.
3. Application to problems.

Note.—Topics VII, VIII, and IX are to be taught in a unified manner.

VII. Ratio and proportion.

1. Meaning of ratio.
2. Meaning of proportion.
3. Application to problems.

VIII. Similar figures.

1. Discovery of relationships.
2. Development of idea by problems.
3. Use in drawing maps and plans.
4. Measurement of inaccessible distances.

IX. Graphing.

1. Review of seventh grade work.
2. Problems requiring representation of ratios and per cents by graphs.
3. Construction and interpretation of broken line graphs.
4. Showing functional relation by graphs.

At its future meetings the committee proposes to fill in the outline by naming minor details necessary for perfect development. For instance, it proposes to name what formulas shall be presented and in what order, what types of problems can be used from life and industry and when, what graphs had best be required and along what lines can exploration be made most easily by the pupil.

It proposes to get at the problem of consistent use of terms, for it finds the complaint that the pupil is unable to distinguish between "gain" and "rate of gain," between "sum," "amount," and "principal," etc. It finds that most texts are not consistent in the use of certain expressions. One problem may read: "A sum of money will amount to ———" and a little farther on the pupil will find this: "Two men form a company and their capital amounts to ———". While the number of such inconsistencies in arithmetic cannot be large, yet why should there be a single case?

Articulation Committee for Mathematics, Lake Shore Division Illinois Teachers' Association.

Elma Englebrecht, Elgin
Winifred N. Tobin, Elgin
Herma Wyman, Wilmette
Mary M. Reese, Winnetka
Florence Connor, Oak Park
Elsie L. Davis, Maywood
Alice Jamison, Oak Park
Edwin Schreiber, Maywood
Geo. A. Harper, Kenilworth
Sara Grant, Maywood
Beryl Van Antwerp, Evanston
Stella Stevenson, Evanston
C. M. Austin, Oak Park, Chairman
M. J. Newell, Evanston, Secretary

ORIGIN OF THE NAMES ARITHMETICAL AND GEOMETRICAL PROGRESSION AND PROPORTION.

By Florian Cojori,

University of California, Berkeley.

"You shall also understande, that there are infinite kindes of Progressions, but for you (as yet) two are sufficient to be exercised in, of whiche the one I call Arithmeticall, and the other Geometricall." *Robert Recorde*, about 1543.

Arithmetical and geometrical progressions occur in old mathematical records of the Babylonians and Egyptians. Finite series of these two types are found about two thousand years before the *names* "arithmetical" and "geometrical" proportions and progressions were introduced. We have not been able to find this terminology in the works of Euclid, Apollonius and Archimedes. These authors use the term "proportion" without the qualifying adjectives "arithmetical" or "geometrical." The phrasing used by Archimedes in connection with magnitudes in arithmetical progression is that the magnitudes "exceed each other by an equal (amount)" or they are "magnitudes exceeding by the equal (difference)."[1] On the other hand, terms in geometrical progression are spoken of by Archimedes as simply terms "in proportion." Thus, with Archimedes, Euclid and Apollonius, there was only one kind of proportion, the one expressing the equality of ratios, and this they called simply "proportion." A few centuries later, says T. L. Heath,[2] "confusion was brought in by those (like Thrasyllus) who said that there were *three proportions* (analogiai), the arithmetic, geometric, and harmonic, where of course the reference is to arithmetic, geometric and harmonic *means* (mesotêtes)." We see that, according to Heath, the terms "arithmetical (arithmetike)" "geometrical (geometrike)" and "harmonical (armonike)" as applied to proportions and progressions, were introduced into Greek mathematics very late, namely on or after the beginning of the Christian era.

Our own studies have led to a somewhat different conclusion, namely that these names were used to a limited extent long before the time of Euclid but did not come into extensive use until about the beginning of the Christian era. That they were not used by Euclid, Apollonius and Archimedes, though earlier writers had used them is rather surprising. Perhaps this discon-

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[1] T. L. Heath, *The Works of Archimedes*, 1897, p. CLXXXVI.
[2] T. L. Heath, *The Thirteen Books of Euclid's Elements*, Vol. II, 1908, P. 292.

tinuity would disappear, if the lost works of these three great men could be found. But the more probable explanation is that the scientific ideals of Euclid, Apollonius and Archimedes prevented them from using the word "proportion" in more than one sense, and that they restricted the use of the word to the relation which was the most prevalent and important in their mathematics.

The data on which we base our conclusion that the names "arithmetical," "geometrical" and "harmonical" proportions were used before Euclid and again about 400 years after Euclid, are in part as follows:

(1) Nicomachus in his *Introductio arithmetica* (about 100 A. D.) says in Chap. XXII,[3].

"Now we have the original proportions accepted by all the ancients, both by Pythagoras and Plato and Aristotle, the three most original, the arithmetical, geometrical and harmonic. . . ."

(2) Jamblichus[4] states: "Formerly, in the time of Pythagoras and the mathematicians under him, there were three means only, the arithmetical, the geometrical, and the third which was known by the name of 'subcontrary,' but which Archytas and Hippasus designated as harmonical, since it appeared to include the ratios concerning harmony and melody."

Thus, Jamblichus attributes to the Pythagoreans the knowledge of the three *means*, but makes no statement relating to the Pythagorean use of the three proportions. On the other hand, he attributes the *name* "harmonical" to mathematicians antedating Euclid; Nicomachus attributes it to Philolaus. Moreover, Jamblichus gives a reason for the use of this term. We should explain that the "harmonical mean" between a and b is $\frac{2ab}{a+b}$ and that the "harmonical proportion," as defined by Jamblichus, is $a : \frac{a+b}{2} = \frac{2ab}{a+b} : b$; in which the second and third terms are respectively the arithmetical and harmonic mean between a and b. The question arises: Is the use of the names "arithmetical" and "geometrical," when connected with the nouns "mean" and "proportion," also pre-Euclidean? Or did Jamblichus and Nicomachus use terminology originating after the Christian era to describe mathematical results reached by

[3]George Johnson, *The Arithmetical Philosophy of Nicomachus of Gerasa*, Lancaster, 1916, p. 44, 46.

[4]Jamblichus, *In Nicomachi arithmeticam introductionem liber*, Ed. Pistello, 1894, p. 100.

[5]*The Nicomachean Ethics of Aristotle*, translated by R. W. Browne, London, 1880, Bk. V, Ch. III, p. 124, 125.

Pythagoreans before the time of Euclid? Our interpretation is that this terminology is pre-Euclidean. Fortunately any lingering doubt can be removed by a quotation from Aristotle which follows.

(3) Aristotle[5] uses mathematics in the study of ethics. The distribution of justice implies four proportional terms. He defines a proportion A:B=C:D as an "equality of ratio," and says: "Mathematicians call this kind of proportion geometrical, for in geometrical proportion it comes to pass that the whole has the same ratio to the whole which each of the parts has to the other," i. e., that A+B:C+D=A:C. Here all doubts about the name "geometrical" are removed, since "geometrical proportion" occurs in a document written before Euclid's time.

As to the reasons for the terminology in question, sufficient has been said relating to the word "harmonical." As to "geometrical," Nicomachus (Chap. XXI, 1) states that geometrical proportion "is the only one termed proportion in the strict sense, because its terms are viewed as in the same ratio the one to the other," that is, it was the proportion *par excellence*, which one finds in Euclid, Archimedes, Apollonius and some of their predecessors. But these mathematicians used ratio predominantly *in geometry*. Euclid's theory of proportion is one of the most conspicuous features in his geometry. This consideration affords a satisfactory explanation why this proportion came to be called "geometrical."

Terms in geometrical *progression* may be considered as terms that are in continual geometrical proportion. Thus, in the progression 1, 2, 4, 8, 16 we have 1:2=2:4=4:8=8:16. Euclid's phraseology rests upon this view point. Terms which were said by later writers to be in "geometrical progression" he described as terms "in continued proportion."

The operation of finding equal differences of numbers is less intimately and exclusively associated with the Greek geometry and more intimately with arithmetic than the operation of finding ratios. Hence the "proportion" in which, a, b, c, d yield a—b=c—d, was called an "arithmetical proportion."

The Greek arithmetic of Nicomachus received commentaries from Jamblichus and was elaborated several centuries later by the Roman Boethius whose Latin works on arithmetic and geometry were studied in western Europe during the later Middle Ages and the Renaissance. Thus the Greek terminology descended to modern times.

From what we have said, it appears that in the works of Euclid, Archimedes and Apollonius there was only one relation of magnitudes which was called "proportion," that before their time the adjectives "geometrical," "arithmetical," and "harmonical" were used occasionally, but they did not meet with wide adoption until about 400 years after Euclid, in the writings of Nicomachus, Jamblichus, Boethius and others. The three adjectives came to be applied to means, proportions and progressions, because these adjectives indicated the field (geometry, arithmetic or music) in which each of the means or proportions had found its most specific application.

THE ATOM OF THE CHEMIST.

By W. H. Rodebush[2].

The chemist has believed in the existence of the atom for more than one hundred years. The fact that the different elements combine to form compounds in certain definite proportions by weight can be most easily explained by assuming each element to be made up of discrete particles all of the same mass in a given element but of different masses for different elements. But while this explanation of the laws of chemical combination was the only satisfactory one that could be offered, nevertheless, until a few years ago, not a single direct proof of the existence of atoms had been obtained. As a matter of fact, about twenty years ago a school of chemists arose, headed by Ostwald, who doubted the existence of atoms. They said the atomic theory was an attempt to explain nature by a crude mechanical analogy and that matter was not the coarse grained sort of affair that these literal minded people made it out to be. They said that the people who believed in atoms did so because they had a psychological intuition which they got from observing dust particles. One can divide a dust particle into finer and finer particles, but the imagination balks at continuing this process of division indefinitely. So these literal minded people thought that one must ultimately arrive at a particle of such fineness that it could not be further divided and hence, the indivisible atom. Likewise said the antagonists of the atomic theory, these people think of a liquid like water not as a fluid but as a discontinuous medium made up of hard solid molecules which were free to slide over

[1]Paper read before the Illinois State Academy of Science, April 27, 1922.
[2]Associate Professor of Physical Chemistry, University of Illinois.

one another, for the reason that the human mind grasps the idea of particles of unchanging size and shape much more readily than it does that of fluid matter. And so a gas, instead of being a continuous medium able to expand indefinitely, must be made up of hard elastic particles flying about in space.

On the other hand, these literal minded chemists, and they comprised a great majority, went ahead serenely building up a system of chemical combination based upon the assumption of indivisible atoms—a system which has proved extremely fruitful in bringing the facts of chemistry, especially organic chemistry, to light and which constitutes one of the most remarkable achievements of human intelligence. Within the last few years, by a series of brilliant experiments, the existence of the atom has been established beyond a doubt. For most of the direct evidence of the existence of the atom we are indebted to the physicist. But the physicist was not content with demonstrating the evidence of the atom. He has gone ahead and shown that the atom is made up in turn of electrons and positive nuclei and is of such complexity as to defy our comprehension. His work has proved that both schools of chemists were wrong. Atoms exist but they are not the hard indivisible particles that the chemist thought them to be. They are perhaps nothing but systems of electrical particles. These particles themselves are nothing but centers of electrical force. There is nothing left for the man whose imagination works through his tactual sense to rub between his fingers and say, "This is matter." The man who was happy with hard, indivisible atoms is no more comfortable with this complicated atom that the physicist has forced upon him than he would have been in the old days without any atoms at all.

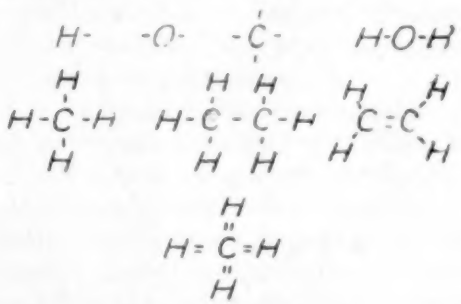


FIGURE I. STRUCTURAL FORMULAE FOR COMPOUNDS ACCORDING TO THE CLASSICAL VALENCE THEORY.

The chemist is interested primarily in the ability of atoms to combine with atoms of other elements to form chemical com-

pounds. The numerical measure of the ability of an atom to combine with other atoms has been called its valence, and the force which binds one atom to another, as to the nature of which we have been until recently very much in the dark, has been designated as the valence bond. By ascribing to hydrogen one valence bond, oxygen two and carbon four, (Fig. 1) the organic chemist has built up a most extraordinary system of chemical valence which not only applies almost perfectly to several hundred thousand compounds, but which may almost be said to predict the existence and the properties of this vast number of compounds as well as innumerable other compounds which yet await syntheses in the laboratory.

When we come to inorganic chemistry, the situation is different. In the first place, the valence of many of the elements is not a simple, definite number, but is a variable quantity, some of the elements having as many as seven different numerical valences. In the second place, the valence bond is a different sort of a thing from the one we met with in organic chemistry. If we electrolyze sodium chloride which has been brought into a liquid condition by solution or melting, the sodium travels in the direction of the positive current and the chlorine in the opposite direction, thus demonstrating that the sodium atoms are positively charged and the chlorine atoms negatively so. It has been recognized since the time of Faraday that the attraction of the positively charged sodium atom for the negatively charged chlorine atom would account fully for the valence bond in sodium chloride. It remained for the brilliant researches of Bragg and Bragg to show just how and why this was so. Physical experiments show that a sodium chloride crystal is made up of alternate positive and negative charges (Fig. 2) arranged in a so-called simple cubic arrangement, each positive charge surrounded by

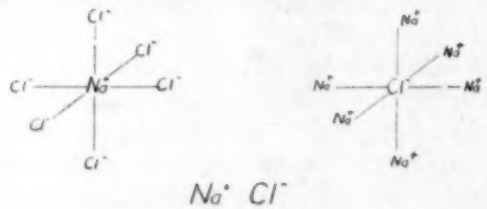


FIGURE II. ARRANGEMENT OF SODIUM AND CHLORINE ATOMS IN THE SODIUM CHLORIDE CRYSTAL.

six negative charges, and each negative charge surrounded by six positives. These charges are not to be confused with the

electron or elementary positive charge, however. For with the positive charge is associated a mass equal to that of the sodium atom and with the negative charge a mass equal to that of the chlorine atom. Evidently, then, we have the charged atoms acting as indivisible units and bound to each other by electrostatic forces alone. In valence bonds of this nature, therefore, number has lost its significance for apparently one sodium atom may attract the six chlorine atoms which surround it with as much force as it would attract a single chlorine atom in a sodium chloride molecule in the gaseous state. Evidently, therefore, if we were to try to write sodium as we do carbon, oxygen and hydrogen in organic chemistry, with a certain number of dashes to represent its valence, we should be at a loss whether to put one dash to represent the sodium atom, or six. With the understanding, however, which the physicist has given us of the structure of sodium chloride, the uncertainty of the valence number causes us no difficulty; rather, the new viewpoint of the matter makes easily understandable the many interesting properties of that large class of substances of which sodium chloride is a conspicuous example, known as electrolytes.

On the other hand, in the case of the organic compounds, where the number system of valence works so satisfactorily, we have no physical evidence as to the structure or arrangement of the atoms in the molecules except that the atoms do not seem to be charged as they are in the case of sodium chloride. We must still rely upon the intuition of the chemist rather than the direct experiment of the physicist for an explanation of the force which we call a valence bond. Many chemists still prefer to regard valence as an abstract numerical property of the atom and content themselves with taking it as it exists without worrying about why it is so. On the other hand, with the conception of the atom as a positive nucleus whose charge is its atomic number surrounded by electrons, a physical chemist believes that valence is not simply a number, but that it can be explained in all cases as due to electrostatic forces between the positive nucleus of one atom, and the outer electrons of the same and other atoms. The theory of G. N. Lewis[3] has met with most remarkable success in explaining the combination of atoms in the molecules. This theory is based upon the conception of the atom which the physicist has given us and I shall try to sketch for you its essential features.

[3]Journal of the American Chemical Society, *38*, 762 (1916).

Let us consider the elements from lithium to neon inclusive, which form the first row of eight in the periodic table. (Fig. 3). Lithium has an atomic number of three, the elements being placed according to their atomic number. The atomic number is the number of positive charges on the nucleus and we represent the nucleus of the atom by writing the atomic number with a plus charge after it. The neutral atom then must have as many electrons around the nucleus as it has positive charges on the

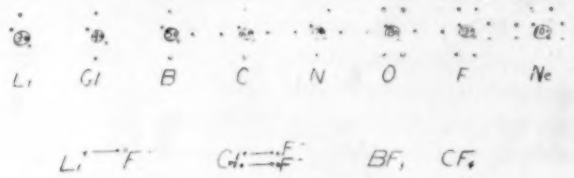


FIGURE III. ATOMIC STRUCTURE OF ELEMENTS LITHIUM TO NEON. POLAR AND NON-POLAR COMPOUNDS.

nucleus. It should be observed that except in the cases of substances like sodium chloride where the atoms are alternately positively and negatively charged, the atoms must be on the average neutral. In our representation of the electrons, we have apparently arbitrarily placed two of the electrons close to the nucleus and the remaining electrons are arranged at some distance away from the nucleus. The following consideration, however, shows the justification for doing this. When lithium combines with fluorine to form lithium fluoride, we get a salt which resembles sodium chloride. The lithium atom becomes positively charged and the fluorine atom negatively charged. This can be brought about only by an electron passing from the lithium atom to the fluorine atom. The lithium atom, however, never loses more than one electron. This is a fact which has been recognized for a long time. Even before the electron was discovered, it was thoroughly understood that the lithium atom could acquire only one positive charge while the glucinum atom combines with two fluorine atoms and acquires two positive charges. That is to say, the glucinum atom may lose two electrons. Since it has four electrons, however, apparently there are two electrons in it just as in the lithium atom which may not be lost. We find the same considerations to apply throughout the rest of this row of elements, and we assume that these two electrons are closer to the nucleus than those electrons which take part in a chemical reaction. Those electrons which take part in a chemical reaction we, somewhat arbitrarily perhaps, assume

to be at a greater distance from the nucleus and designate them as valence electrons. A valence electron, then, is an electron in the periphery of the atom. Lithium has one, glucinum two, boron three, and so on up to neon which has eight. Lithium combines with one fluorine atom, beryllium with two fluorine atoms, boron with three and carbon with four. Lithium fluoride and glucinum fluoride are salt-like in their character, that is, they resemble sodium chloride, and the valence bonds which hold them together may be ascribed to the electrostatic forces between the atoms when an electron passes from one atom to another leaving the one atom positively charged and causing the other atom to be negatively charged. Compounds of this type are called polar compounds because the molecule consists of a positive and negative atom or atoms resembling a magnet with a north and a south pole. The reason that the electron passes so readily from the lithium atom to the fluorine atom appears to be because the positive charge upon the nucleus of the fluorine atom is so much greater than that upon the lithium atom. The recipe for making a polar compound—that is, one of salt-like character, then—is to take two atoms with a considerable difference in the positive charge upon their nuclei. This rule is subject to a modification which will be obvious a little further on. When that modification is introduced, it is found to be verified absolutely by the facts of chemistry. When we consider boron trifluoride, we find that the difference in positive charges upon the nuclei of the two atoms in question is not so great. Therefore, the tendency for an electron to leave the boron atom and go to the fluorine atom will be very much less. As a matter of fact, boron trifluoride does not appear to be a polar substance, that is, of salt-like character, and when we consider carbon tetrafluoride, where the fluorine has only three positive charges more than the carbon, we have a compound which has no resemblance whatsoever to a salt. There is no reason to believe that the electron has left the carbon atom and gone to the fluorine atom, and we are forced to the conclusion that the valence bonds here must be quite different in character from those in lithium fluoride. G. N. Lewis has proposed the theory that the valence bond in a compound of this non-polar type consists of two electrons occupying a position somewhere intermediate between the two atoms. (Fig. 4). We cannot here go into the detailed considerations which led Lewis to the idea that a non-polar bond consisted of two electrons. We can only try out the

arrangement of a number of compounds to see how it will work out and, of course, that is in the last analysis the only consideration of importance in regard to any theory. It may be noted at once, however, that if two electrons are to be placed between atoms for each valence bond, it will in general lead to an even number of electrons in any molecule. Remarkably enough, all but a very few of the hundreds of thousands of chemical compounds do contain an even number of electrons. It may be noticed that if we take the old valence theory of organic chemistry where carbon has four valence bonds and hydrogen one, and assume that these valence bonds link, not with each other, but from atom to atom, then the electron in the Lewis theory of valence simply replaces the valence bond in the old system. The application of this theory of valence to organic chemistry in general, then, becomes very simple.

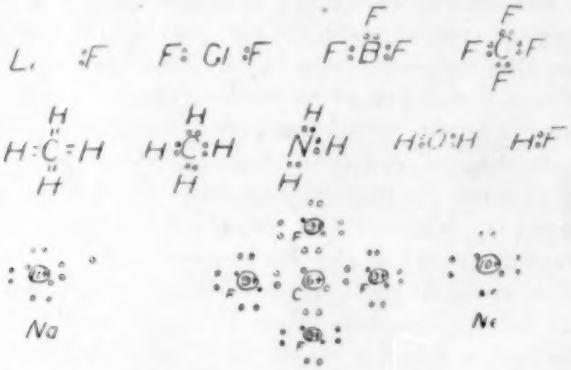


FIGURE IV. SHOWING APPLICATION OF LEWIS' THEORY OF VALENCE TO COMPOUNDS WITH COMPLETE STRUCTURE OF SODIUM, CARBON TETRAFLUORIDE AND NEON.

Since carbon combines with four fluorine atoms, we might expect nitrogen to combine with five and oxygen with six. But no such compounds occur. The reason appears to be fairly obvious. The forces of repulsion between the nitrogen and fluorine nuclei are so great that the atoms refuse to remain in combination with each other. When we come to the neon atom, we find a peculiar state of affairs; neon does not combine with any other atom. We might explain its refusal to combine with nitrogen or oxygen as due to the repulsion of the positive nuclei but there appears to be no reason why it should not take an electron away from a weak atom like lithium. The conclusion which we are forced to is this: Neon has eight electrons in its outer or valence shell. There must be something about the

geometry of the arrangement of eight electrons about an atom, which makes it peculiarly satisfactory to the forces between the electrons. Eight electrons may be comfortably arranged in the outer surface of the atom but no more electrons may be introduced into this arrangement. Sodium, with an atomic number of eleven, resembles lithium in its properties and can acquire only one positive charge. That is to say, it has only one valence electron. We must conclude then that in the sodium atom the eight electrons are in a condition similar to the two electrons in the lithium atom. We then represent the sodium atom as having eleven positive charges upon its nucleus, two electrons close to the nucleus, eight more outside of these two, and the one valence electron still outside these eight forming the beginning of a new shell of outer or valence electrons. The second row in the periodic table thus becomes a repetition of the first row (Fig. 5), the number of valence electrons increasing with the atomic number until we reach the rare gas argon, the only difference being that the second row has an inner shell of eight electrons. The chemical properties of these elements bear out this conclusion absolutely. If time permitted, we could go on through the periodic table of elements, showing how the properties of these elements may be explained by assuming that the electrons are arranged in series of shells, one about the other, the outer shell always composed of the valence electrons.

Since this group of eight seems to be a peculiarly stable arrangement for the electrons about an atom, we should expect that those atoms which have less than eight electrons in their outer shells would try to acquire eight electrons when they enter into a chemical compound. This proves to be the case. It does not apply, of course, to those atoms which are relatively weak, that is, those atoms which have a small positive charge upon the nucleus, because we have seen that when they enter into chemical combination they lose their valence electrons entirely. But, for the atoms beginning with carbon, which do not lose their valence electrons to another atom in a chemical combination, we find in a vast majority of cases they combine with other atoms in such a way that they complete their shell of valence electrons up to the number eight. An inspection of such typical compounds as carbon tetrafluoride, methane, ammonia, water and hydrogen fluoride (Fig. 4), will show that this is the case. The hydrogen atom, it may be remarked here, with only one positive charge upon its nucleus and only one electron of any

kind, appears to be completely satisfied with two electrons instead of eight. But this is what we might expect since we have been led to the conclusion that all atoms have two electrons arranged very close to the nucleus. Hydrogen and helium with atomic numbers of one and two, then, are to be placed in a series by themselves at the beginning of the periodic table (Fig. 5)—the hydrogen atom anxious to acquire two electrons by chemical combination and the helium atom, having two electrons already, refusing to combine chemically with anything. Helium gas is absolutely unreactive chemically.

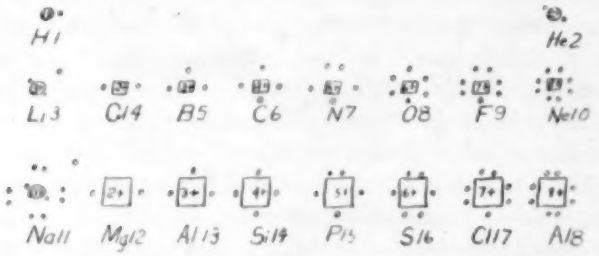


FIGURE V. FIRST 18 ELEMENTS OF PERIODIC SYSTEM. IN THE DIAGRAM OF THE ELEMENTS MAGNESIUM TO ARGON, THE INNER PORTION OF THE ATOM, EXCLUSIVE OF THE VALENCE ELECTRONS, IS REPRESENTED BY ITS NET POSITIVE CHARGE.

The chemical properties of any atom, then, are to be explained by the number of valence electrons it possesses and the pull upon these valence electrons exerted by the positive nucleus. If the pull exerted by the nucleus is very strong, as in the case of chlorine which not only retains its valence electron with great force but strives to acquire additional ones, we say that the element is electronegative. If the force upon the valence electrons is weak, as in the case of sodium, we say that the element is electropositive, meaning, of course, only slightly electronegative since all atoms must be regarded as exerting some pull on their valence electrons and hence being electronegative to some degree. Now the concept of atomic number would lead us to expect that the atoms would increase continuously in electronegativety from hydrogen, with an atomic number of one, up to uranium with an atomic number of ninety-two, since the force upon the valence electron should be proportional to the atomic number by the ordinary laws of electrostatics. As a matter of fact, the electronegativety is a periodic function of the atomic number. The atoms may be arranged in the well known periodic table in periods of two, eight, eight, eighteen, eighteen, thirty-

two and thirty-two. The electronegativety rises to a maximum at the end of each period and drops almost to zero at the beginning of the next period, and the greatest electronegativety in the whole periodic system is reached in the element fluorine[4] with an atomic number of nine. It was to explain this periodicity of the elements that Lewis[5] and Kossel[6] introduced the concept of shells, concentric about the atomic nucleus. Each period ends in an inert gas where presumably a shell of electrons is completely filled. With the first element in the next period, then, there must be the beginning of a new shell. Thus sodium has one valence electron forming the beginning of the second shell of eight around the first shells of two and eight, each in the interior of the atom. The first question, then, that arises, is why does the positive nucleus exert so slight a retaining force upon this valence electron? The answer seems to be this: The valence electron is at a considerably greater distance from the nucleus than the inner shells. The electrons in the inner shells tend to neutralize the attractive force upon the positive nucleus upon this valence electron. The whole sodium atom then exclusive of this valence electron, may be regarded as having a net positive charge of one only, which acts as though it were centered in the nucleus. The force exerted, then, upon the valence electron will be relatively weak. Furthermore, the valence electron of sodium is farther from the nucleus than the valence electron in the lithium atom. Thus, according to Coulombs' law, the force exerted upon an electron by a positive charge is inversely proportional to the square of the distance between them. The electron in the sodium atom is then at a greater distance from the nucleus than in the lithium atom and should be retained with less force. This is the case. Sodium is less electronegative than lithium. This explanation may be applied consistently to the properties of the elements throughout the periodic table. The electronegativety rises to a maximum at the end of each period but each maximum is actually less than the preceding as we go from one period to another, because of the increasing distances of the electrons from the positive nucleus.

This application of the laws of electrostatics to explain the properties of the atom must be recognized as being only quali-

[4]Actually neon may be supposed to be more electronegative than fluorine but since it does not combine with other elements it is not ordinarily so considered.

[5]l. c.
[6]Ann. der Physik 49, 229, (1916).

tative. The unsolved problem is why this arrangement of electrons in shells around a positive nucleus is stable at all. Undoubtedly there is something in the geometry of arrangement of electrons which determines how many electrons may be crowded into any shell. When we study the properties of the more complex atoms we find evidence that the outer shells are no longer perfectly definite arrangements in number but that they are more or less variable in their makeup. Electrons may apparently shift from one shell to another. But the geometry of the atom can hardly explain why the electrons do not fall into the powerful positive nucleus. That they do not is a fact. Why they do not is a problem for the physicist rather than the chemist.

The importance of symmetry in the stability of electron arrangement should be emphasized We have already mentioned Lewis' observation that so comparatively few of the many thousands of compounds contain a total number of electrons (measured by the sum of their atomic numbers) which is odd. Those which do are relatively unstable and almost without exception highly colored. Apparently when the number of electrons is odd, instead of each electron's having a definite position, one or more electrons are able to oscillate between two or more positions, thus absorbing light of some wave length in the visible spectrum and causing the phenomena of color. It has been noted that many complex atoms have a variable structure in their electron shells. These atoms are all colored.

To repeat, the most important question is, why the shells of electrons do not collapse into the positive nucleus.

The physicist has offered an explanation and a natural enough one. He says that the electrons are rotating around the positive nucleus in orbits just as the planets rotate around the sun, and that they do not fall into the nucleus for the same reason that the planets do not fall into the sun. The chemist has a very grave objection to this dynamic atom of the physicist. The chemist has reason to believe that the atoms are combined in molecules of extraordinary complexity and rigidity of structure. These molecules retain their structure unchanged throughout the ordinary processes of fusion, evaporation and chemical reaction. The chemist believes that the atoms are held together in these molecules by electrons which occupy definite positions between the different atoms. It is almost incomprehensible how these electrons can be rotating around these atoms in orbits and at the same time bind the atoms together in fixed and de-

finite arrangements of molecular structure. Many chemists, therefore, have preferred to believe in the static atom, that is, one in which the electrons are arranged in stationary shells, preferring to leave the stability of the shells unexplained rather than adopt an explanation which appears to destroy the chemical property of the atom we call valence.

The physicist is mainly concerned with the explanation of such phenomena as radiation, and this dynamic theory of the atom explains radiation very well, provided the physicist discards a considerable portion of the classical theory of electrodynamics. He has the same justification in doing this that the chemist has in discarding Coulombs' law as being operative at small distances between electrons and positive nuclei. That is, each explanation seems to fit the facts. The facts which the physicist and the chemist are trying to explain are thus of a different sort. To the chemist an atom which is radiating light is in a pathological condition. It appears to be impossible for an atom to be brought in a condition in which it radiates without destroying the molecule of which that atom is a part. The dynamical theory of the atom, then, explains the properties of the atom in one condition; the static theory explains the properties of the atom when it is in another condition. The two theories then may not be contradictory—they may simply apply to two different states of affairs. The problem to be answered, then, in the immediate future is not whether these two theories may be reconciled, but rather, whether they are dealing with the same phenomena.

INDUSTRIAL CHEMICAL RESEARCH.[1]

By John C. Hessler,

Knox College.

The writer has no thought of entering upon an extended exposition of industrial research, nor upon a description of any special problem, but to give in a few words his impressions of the work done at the Mellon Institute of the University of Pittsburgh, in the hope that these impressions may be, to some of those present, of at least a passing interest.

The Mellon Institute represents, in cement and stone, the ideas and ideals of Dr. Robert Kennedy Duncan. Dr. Duncan, as most of you know, was a pioneer in the popularizing of science, especially chemical science, with the industrialists of America. He was a man of wonderful imagination and of magnetic person-

ality. When he entered a room, he become at once its center; when he spoke, the captain of industry listened. His voice is still heard in the Institute he founded. It was Dr. Duncan's idea that the manufacturer was entitled to the service of men of approved ability, and that the investigator, on the other hand, was entitled to the stimulus and aid which come from companionship with other investigators and the oversight and direction of trained scientific administrators. These advantages the Institute affords.

At the Mellon Institute an industrialist, a company, or an association of manufacturers may become the donor of a fellowship. The conditions are essentially the signing of an agreement stating the relation of the Donor, the Institute, and the Fellow, and the contribution of a foundation sum for a period of not less than one year. This sum must be large enough to permit of the purchase of all necessary special equipment and to pay the salary of the Fellow. The Institute gives the Fellow the room for his work, the use of permanent equipment and library, and the direction of the administrative officers. All results obtained during the course of such a fellowship belong exclusively to the Donor. One can get some idea of the scope of the Institute's work when he learns that during the year 1920-1921, the foundation sums of the Industrial Fellowships totaled $320,848, and that there were 48 fellowships and 83 Fellows. During the ten years ending March 1, 1921, the total contributed amounted to upwards of $1,500,000, while the overhead expenses of the Institute were approximately $470,000.

To come now to the individual Fellowships, the writer recalls very vividly the case of a prospective Donor who was being conducted through the building, and who exclaimed, upon entering the room of the Laundry Fellowship: What on earth has a laundry to do with Chemistry? Of such stuff are many Donors, before they are converted. It happened that the Laundry Fellowship was working upon matters that involved a great deal of Chemistry; not only the routine analyses of soaps, water softeners, water samples, blues, sours, bleaches, and the like, and in the investigation of claims for damage, but also the greater problem of interesting the public in the idea of "sending it all to the laundry," a problem involving not only the renewing of soiled fabrics, but a study of all the complex operations concerned with weaving, dyeing, and composition of fabrics. The new problem of the laundry is something more than the washing

of the collars and "biled" shirt of the bachelor until he gets a wife. The Laundry Fellowship is an Association fellowship, with about 1,800 members behind it.

Other Fellowships bear the names of Synthetic Resins, Bread, Zirconium, Fish Products, Fuel, Plastics, Soap, Enameling, Synthetic Acids, Food Container, Protected Metals, Stove, Sulphur, Oil Shale, Nickel, Flotation, Glass, Oil, Quartz, Gas, Tar Products, Emulsion Flavors, Inks, Cements, Fiber, Yeast, Silicate, Magnesia Insulation, Coke, Organic Syntheses, Insecticides, Glue, Fertilizer, Dental Products, Cleaning, Refractories, Asbestos, Fruit Beverages, and Magnesia Products.

The Bread Fellowship is the oldest, probably, at the Institute, and one of the most successful. It would be hard to overstate the importance of the work of this Fellowship, and of similar work done elsewhere, upon the quality and cost of commercial bread. The processes developed save, probably, half the yeast and half the sugar used in bread-making. One has only to compare the commercial bread of today with that of a few years ago to realize the enormous importance of scientific methods applied to this ancient art of the home.

The Fellowship labeled "Fiber" looks ordinary and uninteresting; but when one understands its ramifications and import, it has a different significance. One of the problems of this fellowship is the testing and development of fiber shipping containers. If one goes through a freight warehouse these days, he is struck with the lack of wooden boxes, and the way in which fiber boxes and cartons have taken their place. The development of containers includes not only the study of the fiber boards, multiple and corrugated, but of the adhesive, which must be cheap and at the same time proof against storage in damp warehouses and exposure to weather.

One of the tools of this fellowship is a miniature Ferris Wheel, operated by a motor and containing a series of baffles, so that a loaded container may, in a few minutes, be subjected to all the drops and bumps of a thousand, two thousand, or three thousand miles. Other tools give the actual strength of the fiber and tape employed.

The Sulphur Fellowship has a number of most interesting problems. You will realize how enormously the production of this element was stimulated by the war, as the starting point in the manufacture of sulphuric acid, which in its turn lay at the foundation of the manufacture of explosives. Now that the war is

over, the companies producing sulphur in the Texas fields have an enormous excess of this element over what the markets can possibly absorb. The question is, how to use the vast sulphur deposits. Perhaps some of those present will have some ideas on the subject. A large scale use which seems possible is as a material for large acid proof containers. Curiously enough, while the sulphur obtained from the deposits by the Frasch process is very pure (often 99.9%), the presence of a trace of oil in the sulphur makes its continued combustion in a sulphur burner difficult, because the oil forms a film which extinquishes the flame. A special burner had to be devised for the purpose.

The Yeast Fellowship, the Flotation Fellowships, and the Coke Fellowship have problems of most far reaching character and are almost research institutes in themselves. Such fellowships are of the type called Multiple Fellowships, in which the Senior Fellow is a man of unusually high research ability, in charge of a group of investigators for the solving of a group of problems.

Fellowships like those on Synthetic Resins, Synthetic Acids, Organic Synthesis, and the Pratt Memorial Fellowship are doing work of a pure-science research character, but often on a scale of which the organic chemist rarely dreams.

The stipend carried by the fellowships at Mellon Institute is by far beyond that allowed in the usual college or university. Since it is paid by manufacturers, accustomed to a business man's scale of compensation for service performed, instead of by Boards of Trustees doling out very limited funds to needy students, there is a possibility of attracting and holding men of university research character to the work of investigation. The advantage of these fellowships is further increased by the fact that by special arrangement with the Donor, the Fellow may spend a limited amount of his time in graduate study or in teaching at the University of Pittsburgh. A number of Fellows have received higher degrees in this way.

The writer will close this paper with the inscription he often pondered upon during his year in Pittsburgh. It is: "This building is dedicated to the service of American Industry and to young men who destine their life work to the industries; the goal being ideal industry, which will give to all broader opportunities for purposeful lives."

[1]Read before the Chemistry and Physics section of the Illinois State Academy of Science, at Rockford, April 28, 1922.

CONCENTRATION OF RADIUM FROM CARNOTITE ORES.[1]

By B. S. Hopkins and G. C. Ruhle,

University of Illinois, Urbana.

Carnotite is a potassium uranyl vanadate of essentially the composition represented by the formula $K_2O.\ 2UO_3.\ V_2O_5.\ 8\ H_2O$. All the mineral substances present are valuable but the most valuable component, radium, is present in such a small proportion that it cannot readily be shown in the formula. It requires a ton of relatively rich carnotite ore to produce 10 milligrams of radium. It is very evident, then, that any method which is efficient in the removal of radium must be capable of effecting practically 100 per cent extraction. It is, also, clear that a very important part in the process will consist in the concentration of the minute quantities of radium after they have been removed from the great bulk of the ore.

For the first step in the process, the United States Bureau of Mines recommends the employment of nitric acid by the use of which practically all the radium, together with most of the other valuable mineral constituents present, is converted to the soluble form. The solution obtained in this manner is nearly neutralized, barium chloride is added, and the radium and barium are precipitated by adding sulfuric acid. The precipitated radium-barium sulfate is filtered off and from the clean solution, uranium is precipitated, usually as sodium uranate, and the vanadium either as ferrous vanadate or calcium vanadate.

The main advantage claimed for this process is the high recovery of radium. The disadvantages arise from the cost of nitric acid and the fact that there is only partial extraction of vanadium. In large measure the cost difficulty is overcome by the fact that a very considerable portion of the nitric acid may be recovered and used again. If the main object in view is the extraction of radium, this method is said to be especially efficient.

The radium-barium sulfate, which contains only a very small per cent of radium must now be subjected to treatment for the concentration of radium. The usual procedure is as follows: The mixed sulfates are reduced to sulfides by heating with charcoal or are converted to the carbonates by boiling with sodium carbonate solution. The sulfides or carbonates so obtained are dissolved in hydrochloric acid and the resulting solutions subjected to fractional crystallization. This method of concentra-

[1]Read before the Chemistry and Physics section of the Illinois State Academy of Science, at Rockford, April 28, 1922.

tion depends upon the fact that when a saturated solution of radium-barium chloride is cooled from 100° to 0° the crystals formed are much richer in radium than the original solution. Accordingly if a solution of the mixed chloride is evaporated until there remains not quite enough solvent to keep all the salts in solution there will be a tendency for the radium chloride to crystallize out, while the mother liquor will become correspondingly richer in barium chloride. After this process has been repeated many times, it is found that the radium is nearly all concentrated in the crystal fractions, while the solutions at the "soluble end" of the series contain no radium.

It has been found that the concentration of radium takes place more rapidly if this process of fractional crystallization is carried out by the use of bromides in place of chlorides. This is explained by the fact that the bromides are more soluble than the chlorides. If a saturated solution of the chlorides is cooled from 100° to 0°, about 50 per cent of the solute crystallizes out; but under the same conditions the bromide solution will give up only about 34 per cent of the salts. Hence, there is a more rapid concentration of the radium if this salt is used.

The concentration of the radium in any fraction may be calculated from the equation:

$$C = AK^n$$

in which n is the number of crystallizations, A is either the actual or assumed concentration of some dish to start with and K called the enrichment factor is a constant, when the crystallizations are carried out under exactly similar conditions. It represents the relative concentration of the radium in the crystals to that in the original material. It has been shown that the enrichment factor is practically independent of the degree of acidity of the mother liquor; likewise that this factor for a bromide system is 2.6 while for a chloride system it is about 1.6. Reasoning from the familiar relationships shown in the periodic table, it might readily be concluded that if a bromide system was more efficient than a chloride system the fractional crystallization of the iodides would be considerably more efficient than either the chloride or the bromide. With this view point in mind, a series of experiments are now being conducted to determine the practicability of an iodide system of radium concentration.

Before this experiment could be carried out successfully, it was necessary to determine the best method of preparing the

iodide solution. Several methods were tried such as: (1) Superheated steam was passed over the sulfide converting it to the hydroxide, which was then heated to a dull red in a stream of hydriodic acid gas; (2) the sulfide was transformed to the iodide by boiling with an alcoholic solution of iodine; (3) the sulfide was added to a boiling solution which contained slightly more than the calculated amount of ferrous iodide; (5) the sulfide was boiled with hydriodic acid solution and a small amount of iodine in hydriodic acid was added. Of these methods the last proved to be the most satisfactory so it was employed.

To test out the efficiency of the halide fractionation systems, three samples of radium-barium sulfate, each weighing 100 grams, were reduced with charcoal and the resulting sulfides were treated with hydrochloric, hydrobromic and hydriodic acids respectively. After the action had ceased they were boiled to expel hydrogen sulfide, filtered and the residues washed thoroly. The filtrates were evaporated to dryness, taken up with a small quantity of water to which was added a little of the free acid and the fractional crystallization begun, by evaporating on a steam bath until the solution were completely saturated. Then the dishes were cooled in ice water, the crystals filtered out, redissolved in pure water and recrystallized.

To test the efficiency of the solvent action of the three halogen acids the residues from the acid extractions were analyzed for their barium content and were found to contain practically the same per cent of that element. Hence, it was concluded that the acid extraction was the same in all cases and that the three solutions presumably contained the same amount of radium.

After several crystallizations of the three halide systems, equivalent amounts of the richest fraction of each were placed in the case of a charged electroscope and the time of discharge noted. The iodide discharged the electroscope more quickly than either the chloride or the bromide, but the work has not yet progressed to the point which will permit a definite statement concerning the value of its enrichment factor. Another decided advantage in the use of the iodide comes from the greater solubility of this salt over the others, hence a given amount of radium in the iodide solution occupies a much smaller volume than it does in the chloride or bromide solution. This permits the use of smaller crystallizing dishes, a material saving on a large scale operation.

[1]John L. Niermann. Jour. Phys. Chem. 24 192 (1920).
[2]C. E. Scholl. Jour. Am. Chem. Soc. 42, 889 (1920).

The use of the iodide for radium concentration would not be practical unless it were possible to recover a large per cent of the iodine at the end of the process. Accordingly when the radium had been practically all removed from certain fractions the barium iodide solutions were saturated with chlorine. The displaced iodine was filtered off, dried and resublimed. The barium chloride solution was evaporated and the crystals used in the precipitation of the next batch of radium-barium sulfate. The iodine was mixed with a little less than the theoretical amount of red phosphorus and water was slowly dripped over the mixture. In this manner hydriodic acid was obtained which was also used in the next series. The recovery was satisfactory, indicating that the operating cost for iodine would be quite reasonable.

THE ARTIFICIAL PRODUCTION OF A ZEOLITE.

By L. Evans,

Shortridge High School, Indianapolis, Ind.

I was required to produce an artificial, i.e., a synthetic substance to replace the natural ore used in commercial water softeners. I inquired of the water softener committee and also of the Wayneite Softener Company and found that any hydrated metallic silicate containing sodium would soften water but that Bergen Hill, N. J., produced about the best ore. I then looked up in a mineralogy the analysis of the Bergen Hill ore. This is called natrolite and is the first of the zeolite series. The approximate formula is as follows:

$$Na_2Al(AlO)(SiO_3)_3.2H_2O$$

A glance at this formula will readily show that the constituents would require a very high temperature to cause fusion. By means of the following calculation I determined the charge for the furnace.

$$Na_2Al(AlO)\ (SiO_3)_3.2H_2O$$

Collecting these constituents in their most available forms,

$$2NaOH,\ 3SiO_2,\ Al_2O_3,\ 2H_2O$$

Then by molecular weights, divided by ten, I had the following recipe:

Sodium Hydroxide,	8.0 g.
Silica,	18.0 g.
Alumina,	10.2 g.

(Note, the hydrogen and extra oxygen in the sodium hydroxide combine to form water which is vaporized in the furnace.)

I placed the charge in a fire clay crucible in a glass furnace and fired it for about 2 hours when, all the charge being fused, I drew the fire and cooled the substance. I then pulverized it and placed it in a dish of water in a steam pressure cooker. I kept it at a temperature of 133°C. and a pressure of 20 lbs. for about two hours. This latter treatment, of course, was to hydrate the silicate which was formed in the furnace. I cooled and dried the substance and tested it by treating a small sample with hydrochloric acid with which it gelatinized. As this is one of the group tests for zeolites I was fairly assured of some measure of success and immediately proceeded to try out the substance as a water softener.

I built a small tower filter, along the lines of a large water softener and packed the finely divided product of my experiment into it. I made up a constant soap using lg. of LUX, 90c.c. of distilled water and 10c.c. of grain alcohol. I tested 5 c.c. of ordinary city hard water and found that it took 46 drops of the soap to break it, that is, to form a suds that would stand for five minutes. I then passed about 10 c.c. of the same hard water through my filter of zeolite and tested it with the soap solution in the same manner. It required but 35 drops to break it which almost spelled success. Only one other thing was required of the product to establish it as a water softener; that after being exhausted by passing an excess of hard water through it, it could be renewed by passing salt brine through it. I killed my substance by passing several hundred c.c. of hard water through it. I then prepared a saturated solution of salt and allowed it to stand in the apparatus about ten minutes after which I washed it out thoroughly with clear water. Then again I passed ten c.c. of hard water through the filter and tested it with the soap solution. This time the renovated zeolite softened the water so that it required but 34 drops of soap to break it which was convincing proof that the new product was a success.

Taking into consideration the small amount of the zeolite that I made and the crude method of having it react with the hard water I am convinced that under the almost ideal conditions of pressure and position found in the commercial water softener the artificial product which was the result of the foregoing experiment would be just as efficient if not more efficient than the natural ore now in use.

The following equations are supplementary and give the reactions of the zeolite with the hard water and the salt brine.

Supplement.

The zeolite reacts with the magnesium and calcium salts which form the hardening matter in the water effecting an exchange whereby these salts are converted into sodium salts which are not noticeable in the water as they do not harden it. This reaction takes place according to the equation:

$$Na_2Al(AlO)(SiO_3)_3,\ 2H_2O + CaH_2(CO_3)_2 -> CaAl(AlO)(SiO_3)_3.2H_2O + Na_2CO_3 + H_2CO_3$$

The foregoing reaction is reversible and when an excess of sodium ions is furnished, as in the case of the brine treatment, the reaction proceeds in the opposite direction as follows:

$$CaAl(AlO)(SiO_3)_3.2H_2O + 2NaCl -> Na_2Al(AlO)(SiO_3)_3,\ 2H_2O + CaCl_2$$

which leaves the zeolite ready for use again.

It would appear from the foregoing that the zeolite could be used indefinitely but the truth of the matter is that the latter reaction is not carried absolutely to completion, though it is very nearly, and consequently the zeolite in time becomes useless and must be replaced.

Specimen report of a high school chemistry pupil in a project class.

[1]The above report was prepared, without assistance, by the pupil whose signature accompanies it. The project was the second undertaken by the pupil. After completing his first project, which dealt with the artificial fixation of nitrogen, he asked to be assigned a project that would require some originality for its solution. He had no knowledge, at the time, of the existence of artificial zeolite processes for water softening so that his solution of the problem was entirely original.

The report is offered as an example of what can be done by a high school pupil under the stimulus of the project method of teaching chemistry. It should be said that the project work occupies only the last two months of the course, and is preceded by thirty weeks of preparation in the fundamentals of the subject.—Frank B. Wade, Shortridge High School, Indianapolis, Ind., June, 1922.

HONORS FOR MEMBERS OF THE UNIVERSITY OF CHICAGO FACULTY.

Among Chicago men who have recently had honorary degrees conferred on them is Forest Ray Moulton, Professor of Astronomy in the University of Chicago, who received the degree of Doctor of Science from Albion College, Michigan, at its recent commencement. Professor Moulton, who received the degree of Doctor of Philosophy from the University of Chicago *summa cum laude*, is a research associate of the Carnegie Institution of Washington and has been for eight years secretary of the astronomical section of the American Association for the Advancement of Science.

Professor Frank R. Lillie, Chairman of the Department of Zoölogy at the University of Chicago, has recently been made chairman for 1922-23 of the division of biology and agriculture in the National Research Council. Professor Lillie, who is also Director of the Marine Biological Laboratory at Woods Hole, Mass., has been President of the American Society of Naturalists and of the American Society of Zoölogists.

A FIFTY-FOOT MERCURY TELESCOPE.

By William F. Rigge,

Creighton University, Omaha, Neb.

Some months ago the press brought the great news that a monster telescope, 50 feet in diameter, was being projected on an entirely novel and reliable principle, such that its construction would not only effect an enormous reduction of cost in comparison with that of existing telescopes, but would also set no limit as to size. The designer proposed to test its capabilities at the opposition of Mars in 1924, and by means of the large-scale photographs it would furnish, to solve the mysteries of our neighboring planet.

The novel principle of this great telescope was the rotation of a fifty-foot basin of mercury about a vertical axis. As the centrifugal force thus developed would urge the mercury towards the rim of the basin, its surface would form a perfect paraboloidal mirror, the very same surface that the most skilled opticians spend years of patient toil in giving to the mirrors of our giant reflectors. By one brilliant stroke of genius the mere rotation of a basin of mercury would thus give us a more perfect and a larger telescope than any that had ever been or could ever be constructed on the old lines.

The boldness of projecting such a monster telescope, and the extreme simplicity of its principle, took most people quite by surprise. Every professor of astronomy has probably been questioned on the matter. And it was long the intention of the writer to examine the case with his readers, but circumstances have prevented it until now. What this article has thus lost in timeliness, will probably be amended by the interest of the subject.

According to a communication signed "(B)" in the February number of *L'Astronomie*, the originator of the idea is a certain B. A. McA., who is praised as an engineer "who manages mines all over the world and owns a steam freighter on the Pacific Ocean." He intends to place his giant reflector in an abandoned mine shaft near Chanaral in Chile, and estimates the cost of the installation at from 150 to 200,000 dollars.

The Principle.

The mathematics of the principle, that the upper free surface of a liquid rotating about a vertical axis takes the form of a paraboloid of revolution, can hardly be called novel. It is mentioned in so many old textbooks that it was most probably

known for centuries. The application of the principle to the construction of a telescope by the actual rotation of a basin of mercury and testing its capabilities on the stars, is also not novel, since it was done in a thorough scientific way thirteen years ago by R. W. Wood of Johns Hopkins University, whose articles on that subject in the *Astrophysical Journal* for March, 1909, and in the *Scientific American* for March 27, 1909, are full of the practical details of his experiment. The only really novel element in the projected monster telescope is its enormous size of 50 feet, which is about six times the diameter of our present largest one, the 100-inch on Mt. Wilson. What the prospects of success are for this giant may best be gathered from Wood's experience with his 20-inch. And this we propose to examine somewhat in detail.

Difficulties with the 20-inch.

Wood says that "the scheme has always been regarded as a joke by astronomers, which is not surprising when one considers the perfection required of an optical surface and the ease with which ripples are set up on a free surface of mercury." However, as great discoveries have at times resulted from a bold attack on age-intrenched principles and on apparently insurmountable difficulties, Wood made up his mind to give the rotating mercury telescope a fair trial. A 7-inch basin worked so much better than he had expected, that he had a 20-inch one made by Warner and Swasey.

He found that there were four distinct sources of the ripples on the mercury. The first came from jars of the driving mechanism. These were eliminated by supporting the basin exclusively on a pivot like a rotating top, and by centering a driving wheel under it without touching it except by the pull of rubber bands. The second was due to the grinding together of the pivot and its socket. These were removed by better workmanship. The third source was the imperfect leveling of the plane inner bottom of the basin. If this bottom, for example, was a millimeter lower than its center on one side and as much higher on the opposite side, there would be with the mercury at rest a depth of two millimeters more on the lower side. After half a turn this part of the mercury would be carried to the higher side and be then two millimeters above the level of the lowest part, so that it would be forced to flow away. This would set up a tidal wave, which would act continuously all over the basin. This difficulty could be easily overcome by setting

the axis of rotation accurately perpendicular to the flat bottom of the dish and then leveling the basin by the stars. The fourth source of the ripples was the most troublesome of all, a want of perfect uniformity in the velocity of rotation. This would change the focal length of the mirror and make the images dance back and forth.

Difficulties with the 50-Foot.

Let us examine what these four sources of trouble would be on the projected 50-foot mirror. To support such a large rotating basin accurately without wobbling and without a variable flexure on one conical bearing, would probably not exceed the capabilities of our modern engineers. But such a support could not be used in the present case, because gyroscopic stability calls for a high rotational speed, which Wood could use with his 20-inch, but which is out of the question here, since for a focal length of 250 feet or 76.2 meters, the 50-foot basin would have to make but one turn in 25 seconds. This would mean a peripheral speed of 1.932 meters or 6.2 feet a second. (Note A.)

This slow speed will compel us to support the basin on wheels running on a circular track. That brings us to the second source of the ripples, the want of absolute mechanical perfection throughout the entire mounting. Even if this were realized at the start, it could not remain so. Railroad men tell us that rails and tires wear unevenly in spots. The mirror must then sag at the worn places. With a focal length ten times the radius of the basin, the deviation of a ray from the rim will be magnified ten times at the focus, and then twice that by the laws of optics. Thus a sagging of only one hundredth of a millimeter or 0.0004 of an inch at the rim means a deviation of one fifth of a millimeter at the focus, and this the keen eye of an astronomer can see even without a magnifying glass. What havoc then will this minute sagging wreak when the focal image is magnified a hundred times or more?

Worse than this is the fact that the mercury will begin to flow to the lower places, and thus start ripples all over the basin. The rotation will then make this "confusion worse confounded," so that a distinct picture at the focus will forever be an impossibility. Springs and other elastic supports would only do harm, because when compressed more or less than usually, they react in proportion and would thus start and keep up vibrations.

Nor would the floating of the basin of mercury upon a second

basin remove all traces of the jarring. The floatation principle has been tried and found wanting. Georgetown College Observatory experimented with a 6-inch floating zenith telescope but abandoned it soon in favor of one of the ordinary mounting. The 6-inch almucantar of the Case School of Applied Science in Cleveland, which uses a circular trough of mercury, has proved to be a disappointment from the start. If floatation cannot satisfy the requirements of the micrometer screw of a 6-inch telescope, how can it give us an optically perfect surface 50 feet in diameter, ten thousand times the area of a 6-inch glass?

The third source, imperfect leveling of the basin or imperfections in the absolute symmetry in shape and mass of the basin with respect to its vertical axis, may prove to be altogether irremovable, when every little roughness, even grains of sand, caused disturbances in the 20-inch.

The fourth source of the ripples in the small mirror, the slightest irregularity in the velocity of rotation, will relegate the practical use of the 50-foot to the realms of the imagination. If in the 20-inch the variation of the focal length of 15 feet or 4.572 meters was finally reduced to a millimeter, what play room will it have in the 50-foot? Computation reveals the fact that a change of but one millimeter in the focal length of 250 feet or 76.200 meters, or of one in 76200, is brought about by a variation of only 0.013 millimeter per second in the peripheral speed of 1932.3 millimeters per second, that is, by a variation in the rotational speed of 0.000,006,56, or of two-thirds of one thousandth of one per cent. (*Note B.*) Even if in spite of this merciless mathematics the variation could be confined within a few millimeters, how will it be possible to see anything distinctly except momentarily? Of course, the designer says he will take his chances and expose a whole series of photographic plates for only small fractions of a second at the mean focus. He evidently expects the images to be otherwise perfect and only move to and fro over a few millimeters. He forgets that mercury is a heavy liquid, and that on account of its great inertia, it will require some time, however small, to mould its surface to the changed speed of rotation and then to relinquish the new shape when the cause for it no longer exists. The inevitable result must then be a distorted surface and a blurred image. The experts that are handling our giant reflectors and focussing them habitually within the thousandth of an inch or the fortieth of a millimeter, might profitably be consulted about an ignis-fatuus focus.

The Focal Length.

The focal length generally used by Wood in his 20-inch mirror was 15 feet, and was obtained, he says, by 12 revolutions a minute. This 12 is evidently a mistake for 10, because 12 revolutions would reduce the focus to 10.18 feet. The ratio of the length to the aperture is here 9 to 1. In the 60-inch Mount Wilson reflector it is only 5 to 1. This we have adopted in the present article. With it we would need a well 50 feet in diameter and 250 feet deep, together with a parallel smaller one to give access to the mechanism, below the mirror. Such a focus of 250 feet or 76.2 meters would make a minute of arc equal to about an inch or 2.2 cm, and the image of Mars when nearest (about 25″) less than half an inch (and the Moon about 30 inches). Perfect definition and impression would of course admit of a wonderful amount of detail being enticed from even much smaller pictures such as are obtained from our large reflectors. But the difficulties and impossibilities already enumerated make the securing of such a perfect picture a hopeless task.

The diurnal motion of the images across the field of view would be about a quarter of an inch a second for an equatorial star. While this could be easily nullified by a proper mechanism, it would be of little practical value, if rigid adherence to the optical axis that the great masters have always exercised, is to be our guide. This would reduce the available time of exposures for pictures free from spherical aberration to perhaps only a few seconds in the 24 hours.

Mounting.

A mercury telescope is evidently directed only to the zenith of the place where it is set up. There is no possibility whatever of pointing it elsewhere, or of attaching a driving clock to it for prolonged observations except by the addition of one or two plane mirrors. A most elementary acquaintance with the heavens tells us that the stars all appear to move with the same angular speed around an axis directed to the pole. In order to keep a star steadily in the field of view of a telescope, we must therefore move either the whole telescope or a plane mirror around a polar axis. If, as is rarely the case, the telescope is permanently set in this polar axis, one mirror making one turn in 24 hours with uniform speed will serve the purpose well. If the telescope is permanently set in any other direction, as the mercury telescope is in the plumbline, we may use either

one or two plane mirrors. If we use only one, it must be given a double movement, the first with uniform speed around the polar axis, and the second about a vertical axis such that its normal always bisects the angle between the direction of the star and the axis of the telescope. Such a mounting is so very complex that it is rarely, if ever, used for a large telescope, except perhaps during the brief duration of a solar eclipse. It is to be found, as a rule, only on small heliostats. Two plane mirrors, one moving around the polar axis, and the other permanently fixed in the axis of the telescope, as is the case in the tower telescopes on Mount Wilson, simplify the mounting very much. But then the cost, the imperfections and the loss of light are doubled. As far as the giant mercury telescope is concerned, it is a safe wager that even one plane mirror without its mounting will cost several times as much as all the rest of the outfit.

While two plane mirrors will reach every star above our horizon, the use of only one will deprive us of all the very best positions of celestial objects, those namely that are high up in the sky. A simple analysis will tell us that, while it must be of course 50 feet wide, it must be at least twice as long to reach stars within 30° of the horizon, while lengths of 3, 4, 5, 6 times its width will carry it up to about 51, 61, 67, 71 degrees respectively. (*Note C.*) When Wood approves of the use of such a plane mirror for mercury telescopes as large as 36 inches and intends to drive it by clockwork or *by hand*, and says it is to reflect the light from *any part* of the sky to the bottom of the pit, he has evidently given this item little consideration.

The Very Limited Range.

If we decide to dispense with the plane mirrors, the mercury telescope is permanently directed to the zenith, so that only those objects can be observed that pass through the zenith or so near to it that spherical aberration is a negligible factor, that is, objects whose declination equals the latitude of the place within a few minutes of arc. Before going to all the expense of erecting such a 50-foot telescope, it would be a matter of only the most rudimentary prudence to fix the proper latitude for it, so that the most and best celestial objects might be observed. Stars, and clusters of them, and nebulae with the same declination are too few to give us a proper return for our outlay. Planets, and Mars most of all, are the game worth hunting. But—and here we must investigate very thoroughly—what is

the declination of Mars, or rather what is its most frequent and best declination? To observe the planet when it is nearest and largest, on August 22, 1924, we must place the telescope in latitude 17° 35′ south, that is, in the Andes near Cailoma in Peru, about 50 miles north of Arequipa, at Flores in Brazil, or on intermediate ground in Peru, Bolivia and Brazil. If we prefer to go to Africa we have choice of Huilla in Lower Guinea, and Mozambique, the capital of Portuguese East Africa, and intermediate places. A third choice is in Australia. A fourth one in the islands of the Pacific may disturb the mercury by the pounding of the waves. Every mile that we go north or south of 17° 35′ south latitude will shift our planet about one minute of arc in the field of view. How the designer of the giant mercury telescope expects to observe Mars with it on August 24, 1924, in Chañaral in Chile in latitude 26° 18′ south, the writer leaves to wiser heads to divine.

With a scale of a minute arc to an inch and an allowable run of ten minutes of arc north and south, east and west, of the optical axis of our 50-foot mirror, we will find that at the opposition of Mars in 1924 we could observe the planet only from August 20 to 24, that is, only on five nights. As the diurnal motion is a quarter of an inch a second, or one minute of arc in 4 seconds for an equatorial star, we could observe Mars only during 80 seconds each night (increased to 84 on account of its declination). With everything in perfect order, our monster telescope would allow us $5 \times 84 = 420$ seconds $= 7$ minutes exactly.

However, we will have three other occasions during the same year 1924 of observing Mars. They will occur from January 6 to 9, May 28 to 31 (August 20 to 24 already mentioned), and September 23 to 27. This will give a total of 18 times, so that we will have $18 \times 84 = 1512$ seconds $= 25$ minutes 12 seconds at our disposal. These four occasions are however by no means equally favorable, as Mars comes to the meridian on January 7 at 8:15 a. m., on May 29 at 5:01 a. m., on August 22 at 12:16 a. m., and on September 25 at 9:40 p. m., its semidiameters or proportionate sizes being respectively 2″.36, 6″.28, 12″.56, 10″.46. With the satisfaction that we have utilized the 25 minutes 12 seconds offered us in 1924 to the very best of our ability, we will have to give our big giant a correspondingly big rest, as far as Mars is concerned, for 15 years. (*Note D.*)

In case the designer should actually place his giant mercury

telescope in the mountains near Chañaral in Chile, it may be of interest to investigate how "favorable" its latitude of 26° 18′ south will be for the purpose. "B," the writer in *L'Astronomie*, says that "the inhabitants of Mars are not to be the only beneficiaries of the project, because those of the moon, if there be any, will also have their rights, and these latter will cross the zenith of Chañaral much oftener than their comrades." First as to Mars. If we take as typical the 15-year cycle between the oppositions of 1909 and 1924, Mars, according to the *American Ephemeris*, came within ten minutes of arc of the zenith of Chañaral only on 32 nights, and these were bunched together in three groups, June 25-29, July 22-August 11, September 20-25, in the one year 1922. Then as to the moon. As this presents a large disk, about half a degree in diameter, let us allow a distance of half a degree between its center and the zenith. If we then again take a former cycle as a typical one, some part of its disk was observable, in theory at least, once or twice in a lunation, in all consecutive phases throughout the year, from April 1, 1892, to March 14, 1898, and then no more until October 20, 1909, when another six-year period of visibility began, to be followed by another eleven-year one of invisibility. The sun, of course, will never be observable in Chañaral's giant mercury mirror. A position within the tropics, especially near the equator, would be vastly more useful. It could observe the sun twice a year, the moon twice every month, and all the planets some time or other.

Is the Mercury Telescope Practical?

After what has been said it is rather surprising to find Wood so optimistic about the future of the mercury telescope. He thinks that "an instrument of large size could in this way be placed within the means of any amateur observer," since his 20-inch with motor, cement pit, entrance shaft, tunnel, etc., cost only 200 dollars. (*Note E.*) He adds, however, cautiously: "Whether a gigantic reflector mounted in a suitable latitude would enable us to see more of planetary detail, I do not feel prepared to say. We could in this way combine great focal length and immense light-gathering power, but we should still have the atmospheric disturbances to contend with." To show the perfection of his mirror Wood gives photographs of an incandescent lamp and of his own countenance. But the really crucial test, a photograph of a starry field, he does not give at all.

To dampen the ripples Wood proposes two methods. The

first is to use a copper vessel turned to an approximate paraboloid and to cover it with only a thin film of mercury, and the second to cover the mercury surface with a thin layer of water or glycerin. The first method has never been tried, but in the second glycerin gave most encouraging results. In a third method he poured hot liquid resin on the mercury, which when cold and solid furnished a pretty good convex paraboloid. When this is electrotyped, he says that a concave paraboloid may be made from the convex one, then electrotyped and silvered at small expense. I am sure that no optician would be enthusiastic enough to pronounce such a surface optically perfect. If this copying process is so easy and so perfect, it would be easier still to make moulds of our big reflectors and reproduce them in great numbers and at little cost. No, future large mirrors with fixed foci will be figured of solid material as before, possibly made in sections and assembled, and the mounting will be of the equatorial type as usual, because that commands the entire sky at all times. And lastly, the fact that the rotating mercury mirror has not been heard from since 1909, is a silent practical proof of its inefficiency.

NOTE A.

Let the curve VP in Fig. 1 be part of the parabola generating the paraboloid, $FAVT$ its axis of revolution, F its focus, V its vertex, $FV = f$ the focal distance, its equation being $y^2 = 4fx$. Let P be any

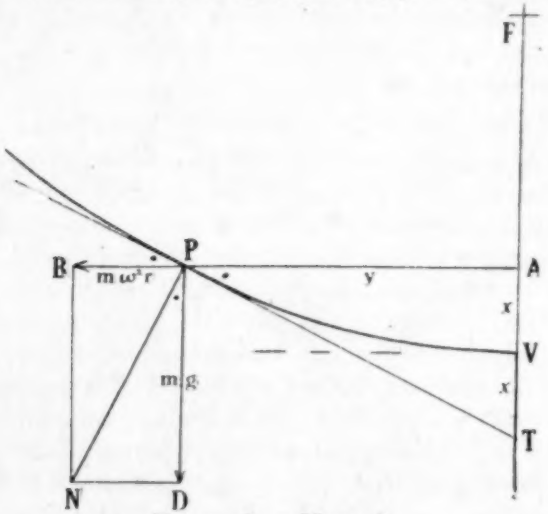


FIGURE 1 IN NOTE A.

point in the basin, y its ordinate and x its abscissa, the tangent at the surface of mercury PT, and the normal PN. Two forces are acting on ω, gravity mg pulling downward along PD, and the centrifugal force

mw^2r throwing it away from the axis A, ω being the rotational speed in radians. As the two triangles NPD and TPA are similar $m\omega^2r/mg = 2x/y$. As $r = y$, and $y^2 = 4fx$, we get $\omega^2 = g/2f$, showing that the focal length is inverselay as the square of the rotational speed, that this angular speed is the same everywhere, and that the specific gravity of the liquid is of no consequence. Substituting the value of $g = 980$ cm and $f = 7620.0$ cm, we find $\omega = 0.25358$ radian per second. Dividing this by 2π gives 0.04036 revolution per second and its reciprocal 24.778 seconds as the time to complete one turn. Multiplying the radian per second by the radius of the basin, gives 193.23 cm per second as the peripheral speed. The height of the liquid at the rim is 19.05 cm or 7.5 inches above that at the center. "B" in *L'Astronomie* thinks that the fifty-foot mirror ought to make about one turn a second. This would give it a focal length of 12.4 cm or nearly 5 inches, instead of 280, 360 and 600 feet that he expects. If he means one turn a minute, $f = 1{,}466$ feet.

NOTE B.

Differentiating the equation $2f\omega^2 = g$ with respect to both f and ω, we find $d\omega = -(\omega/2f)df$. Taking df equal to one millimeter, we get $d\omega = 0.000{,}001{,}664$ radian per second, which multiplied by the radius of the basin states that a change of 0.001,268 cm per second in peripheral speed is sufficient to change the focal length of 250 feet or 76,200 meters by one millimeter. Comparing this with the peripheral speed used, 193.23 cm per second, we get a ratio of 0.000,006,562 to unity, or of one to 152,400. Wood's fluctuation of one in 4,572 millimeters makes his $d\omega = 0.000{,}113$, about one hundred times that for the 50-foot, giving a ratio of 0.000,109 to unity, or about 16 times our requirement.

NOTE C.

In Fig. 2 let $ABCD$ be the tube of the telescope, $MA = m$ the mirror,

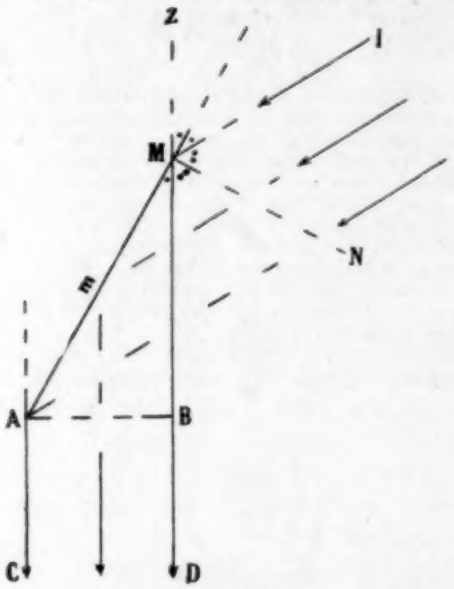


FIGURE 2 IN NOTE C.

and MN its normal. The one-dotted angles θ are equal. Taking the aperture AB as unity, $m = \mathrm{cosec}\,\theta$, and the zenith distance IMZ of the incident ray 2θ, its altitude $90-2\theta$. In the annexed table different integral values of m are given in the first column, and the corresponding values of θ, 2θ, and $90-2\theta$ in the other columns.

m	θ	2θ	$90-2\theta$
2	30° 0′	60° 0′	30° 0′
3	19 28	38 56	51 4
4	14 29	28 58	61 2
5	11 32	23 4	66 56
6	9 36	19 12	70 48

NOTE D.

This does not mean that Mars will not pass at all through the field of view of the great telescope, but that, what astronomers call a very favorable opposition cannot occur again until after 15 years. Mars is in opposition to the sun at intervals of about two years and two months, and is then nearest the earth for the time being, but owing to the eccentricity of its orbit its distances then may vary from about 35½ to 61 million miles. The most favorable opposition is then the one at the least distance, and takes place near August 28. This can happen only once in 15 years.

As the future positions of Mars until the next opposition of 1939 are not available to the writer, he has searched the *American Ephemeris* for the past 15 years, and found that between the last favorable opposition in 1909 (at which Mars had the declination 4° 9′ south, so that this telescope could not have seen it) until the next one in 1924, the planet had the declination 17° 35′ south within 10′ on 33 occasions. The average size of its semidiameter was about 3″, the minimum being 1″.99 and the maximum 4″.65 (except 6″.28 in May, 1924). About half of the transits occurred in the day time within four hours of noon.

NOTE E.

Wood here evidently leaves out of consideration the cost of the plane mirror which he recommends. As this must be optically perfect also, its price will at once dampen the ardor of an enthusiastic amateur. About a year ago the writer needed a pair of plane mirrors, one 4½x2, and the other 4½x1½ inches, for an experimental range finder. The first American firm approached upon the subject asked 120 dollars, the second 80, and a German one 60. Now for Wood's 20-inch we would need a plane mirror at least 20x40 inches = 800 square inches. At the lowest price of 3 dollars per square inch, this would make 2,400 dollars. What discount may be expected on such a large order, we are not prepared to say. Even if it were as high as 60 per cent, the plane mirror alone without its mounting would cost about five times as much as the rest of the outfit. We will not deprive the reader of the pleasure of figuring out the cost of a plane mirror for the 50-foot telescope.

HOOKE'S LAW AND YOUNG'S MODULUS APPARATUS

By G. E. Ripley,
University of Arkansas.

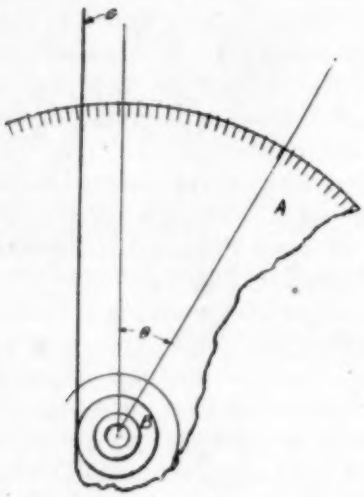
It is not often advisable to try to do too many things in one experiment especially in general laboratory work of first year physics but the combining of Hooke's Law and Young's Modulus does seem highly desirable provided satisfactory apparatus is available. Engineering students should test experimentally both of these important physical principles because of their broad application to engineering problems. It does not however appear advisable to take the time for two separate experiments when the time allowed for laboratory work is so limited.

Hoping to find a satisfactory answer to this problem the writer began experimenting to determine whether or not a convenient simple accurate piece of apparatus could be discovered that would meet the demand. The different types of Hooke's Law apparatus, Young's Modulus apparatus and Hooke's Law and Young's Modulus apparatus were studied carefully and their defects noted. Most of these pieces were found unsatisfactory for several reasons. The cathethometer method was unsatisfactory for two reasons, first the elongation could not be read very closely and second it was difficult to keep the cross hairs on the index point on the wire. The optical mirror method was troublesome and very tedious. The micrometer and spirit level apparatus gave trouble in adjusting the wires and in setting the level. The two-wire vernier type was far from satisfactory. The problem appeared to be one of finding an entirely new kind of apparatus. After considerable time and experimenting the following piece of apparatus was worked out and it has proved highly satisfactory.

With this apparatus the testing of Hooke's Law and Young's Modulus for different kinds of wires has been carried out accurately, quickly and with no trouble or delay to the student. In many

cases the readings "ran so true" that the "on and off" readings gave practically no error. In most cases after the wire had been "run" once the zero readings for on and off would check to the degree of accuracy that the readings permitted.

A glance at the figure shown above will make clear how the apparatus works, how simple it is and how easily manipulated by the student. We have found that it gives no trouble, is easily understood and the results obtained are highly satisfactory.



A small wheel A about twenty centimeters in diameter with an axle B about two centimeters in diameter is carried by a rod G, the latter resting in support D. D also carries clamp for holding wire to be tested. The lower end of rod G is held loosely by collar and set screws at E. This is arranged so that if support D gives any under load, rod G will give the same amount and wheel A will give the same amount. This corrects on wire any give in support D. The wire to be tested is clamped at D, wrapped around B twice and carries weight holder F at lower end, below axle B. Weights can be put on and taken off without disturbing reading conditions. The whole apparatus is well constrained yet perfectly free for the one motion desired, that of the elongation of the wire to load.

The small drawing shows how the elongation of the wire is measured. The readings on the wheel are taken in degrees and the ratio of the degrees read for each load to three hundred

sixty degrees equals the ratio of the elongation for that load to $2 \pi r$ where r is the radius of the axle B.

The writer shall be pleased to submit further and more detailed information regarding this apparatus as well as tables of results obtained by freshmen students using the apparatus if anyone desires it. We are now securing the best and most satisfactory results from testing Hooke's Law and Young's Modulus with this apparatus.

NEW METHODS WITH THE IMPULSE BALANCE.

By John Mead Adams, Ph. D.,

University of California, Southern Branch, Los Angeles.

The Impulse Balance is an apparatus which measures the force required to stop a stream of water. It is adapted to verifying the Second Law of Motion in the form involving force and rate of change of momentum, instead of the more usual form involving force, mass and acceleration. An early model of it was described in School Science and Mathematics, pp. 520-521, 1914. Since that time numerous improvements have been made. The apparatus at present consists of a vane of one-sixteenth inch brass plate fifteen inches long and two and one-half inches wide, to which is soldered, near the bottom, a funnel of sheet brass two inches in diameter, with a small re-entrant funnel at its mouth and with an outlet at its base. A square hole near the top of the vane admits a supporting bracket, and above the hole there is a fixed counterpoise and an arm projecting at right angles to carry an adjustable counterpoise, the whole being so proportioned that the vane hangs vertically from the bracket when the adjustable counterpoise is not in use. The oscillations of the vane are closely limited by the prongs of a forked stop. A small swift stream of water, regulated by a needle-valve, flows from a nozzle carefully reamed to a cylindrical form, and is directed horizontally into the funnel, so as to strike squarely on the vane. Its impact drives the vane against the further prong of the stop, and the water, completely deprived of its horizontal momentum, is discharged vertically downward from the outlet at the base of the funnel. By properly placing the adjustable counterpoise on the arm, the torque on the vane due to the water may be compensated, and the vane brought back to its equilibrium position between the prongs. Knowing the diameter of the nozzle and the quantity of water discharged during a measured interval of time, both the speed of the water

and the mass stopped per second may be calculated, and hence the rate of change of horizontal momentum where the stream strikes the vane may be found. The corresponding force may be calculated by equating the two opposing torques on the vane.

I have had excellent success in using this apparatus to develop the relation between force and rate of change of momentum, step by step. First, using a single nozzle and varying the rate of flow of the water by the needle-valve, the student obtains an experimental relation, in the form of a graph, between the rate of flow of the stream and the force to stop the stream. It appears from the graph that these two quantities are not proportional, but are connected in some less simple way. The graph is in fact, of course, a parabola passing through the origin. The reason for this complication is seen if it is pointed out that when we use only one nozzle it is impossible to vary the rate of flow without at the same time varying the speed of the stream, and both rate of flow and speed will presumably affect the force required to stop the stream. In other words, when the valve is opened wider, not only is there more water to be stopped per second, but every drop of it is moving faster. Therefore to get at the fundamental relations involved, the experiment must be so arranged as to hold one of these factors constant, while the other varies. We next find the relation between the force to stop the stream and the speed of the stream, rate of flow being constant. To do this, we make measurements on streams from three nozzles of different diameters, all flowing at the same rate. The speeds may be calculated from the common rate of flow and the known diameters of the nozzles, and when plotted against the corresponding forces yield a straight line through the origin. This establishes the result that the force to stop the stream is proportional to the speed of the stream, when the rate of flow is constant, which may be formulated:

$$f \propto v \quad (m/t \text{ constant})$$

Similarly, to find the relation between the force and the rate of flow, speed being constant, we select arbitrarily some common speed to work to, calculate for each nozzle the rate of flow corresponding with this speed, and make measurements on streams flowing at these rates. The measured forces when plotted against the corresponding rates of flow yield a straight line through the origin. This establishes the result that the force to stop the stream is proportional to the rate of flow of the stream, when the speed is constant, which may be formulated:

$$f \propto m/t \quad (v \text{ constant})$$

The two partial results now have to be combined into a single one, which is obviously

$$f \propto mv/t$$

and which may be read: "Force to stop stream is proportional to rate of loss of momentum of stream." This proportion may be made into an equation by introducing an appropriate factor or "proportionality constant," the value of which must be determined from the experimental data. From this point of view "g" in the equation

$$fg = mv/t$$

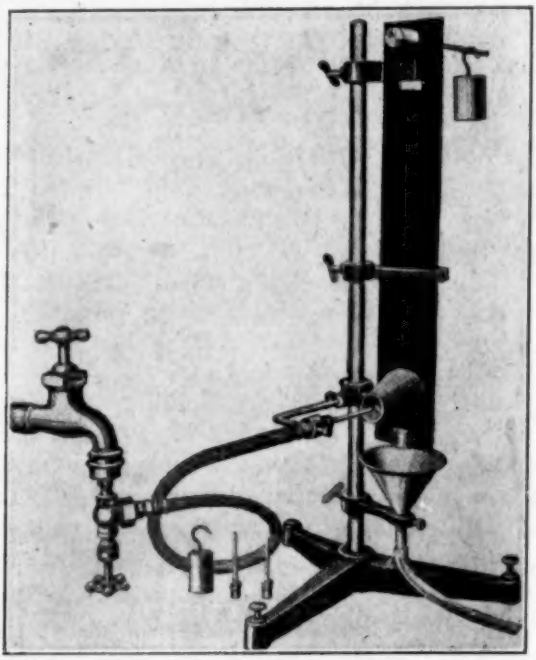
is the factor by which the force in gravitational units must be multiplied, to make the Second Law of Motion numerically correct, in other words the number of dynes or poundals in one gram weight or one pound weight. Substituting experimental values of f, mv/t, and v, we obtain individual values of g correct within two per cent, and the mean of several is correct within one per cent.

Directions for Use.

I. Setting Up.

The apparatus should be used at a sink provided with a hose bibb. Place the tripod stand near or over the sink. Fasten the forked stop about midway the rod, with the prongs projecting in the same direction as the bracket at the top of the rod. Holding the vane vertically, with the square hole uppermost, pass it between the prongs of the forked stop and hang it on the bracket, the knife-edge at the top of the hole engaging the groove in the bracket. (The bracket should enter the hole from the side on which the notched cross-arm projects.) Level the tripod, so that the rod is plumb and the vane hangs parallel with it and midway between the prongs of the stop (slight readjustment of the latter may be necessary). Bring the catch-funnel directly beneath the vane, with a clearance of about an inch. A short length of wide rubber tube, free from sharp bends, may be used to lead the discharged water from the catch-funnel to the sink. A long narrow tube with many bends should be avoided, as it will seriously impair the capacity of the catch-funnel. Screw the needle-valve fitting to the hose bibb, and clamp the delivery end of the hose in the collar on the right-angled rod by means of the set-screw. The right-angled rod itself is clamped in a collar which is adjustable on the main support-rod. Screw the intermediate sized nozzle into the delivery end of the hose. The

position of the nozzle must now be adjusted with the greatest care. The nozzle must be perpendicular to the plane of the vane, with its tip about an inch from and directly opposite to the intake of the funnel on the vane. Several independent movements are available for these adjustments: sliding or rotating of the right-angled rod in its collar, and sliding or rotating the



collar on the main support-rod. With the needle-valve closed, turn on the water at the hose bibb. Gradually open the needle-valve, until the nozzle is delivering about 25 cc. per sec. The stream should appear truly cylindrical, with practically no spreading. If it appears otherwise, there is an obstruction in the nozzle which should be removed carefully without injuring the interior surface. It is absolutely essential that the entire stream enter the funnel on the vane without spattering: slight readjustment of the position of the nozzle may be necessary to accomplish this. The impact of the water is now holding the vane against the back prong of the stop. Hang the larger counterweight on the cross-arm, in the notch where it almost makes the vane swing to the front prong; then close the needle-valve slightly until the vane just swings in equilibrium between the prongs without touching either. This condition of equili-

brium must be maintained at all times while measurements are being made. If there are fluctuations of pressure in the water supply, an observer with his hand on the needle-valve can learn with a little practice to compensate for them almost completely.

II. A Determination of "g."

The Second Law of Motion states that a force applied to a body is proportional to the rate at which it changes the momentum of the body. Whether the force and the rate of change of momentum are numerically equal depends upon the choice of units in which the measurements are made. For example, if masses are in grams, speeds in centimeters per second, time-intervals in seconds, and forces in grams-weight, the rates of change of momentum experimentally obtained will be consistently larger than the corresponding forces by a factor of about 980. To make the law serviceable for numerical computations, it is customary to determine experimentally the factor appropriate to a chosen set of length-, mass-, time-, and force-units, and to embody it in the law in one way or another, the accepted practice among physicists being to alter the force-unit to meet the situation, while engineers prefer to alter the mass-unit. In any case, what has to be done experimentally is to measure both a force and the change of momentum which it produces per unit of time, and then determine the factor which will bring the two results into numerical agreement. This factor, when applied on the force side of the equation, is the familiar "*g*." The Impulse Balance affords a unique experiment for this purpose.

With the adjustments made as indicated above, the water flowing steadily and the vane in equilibrium, catch the water discharged in ten seconds, and measure it in a graduate or on a balance. If a pendulum or clock ticking seconds is used, the observer should count aloud with the ticks "one, two, three, four," and then promptly on the count "five" should thrust the beaker under the spout, holding it there and withdrawing it equally promptly on the count "fifteen." It is a frequent mistake to put it under at the count "one" and withdraw it at the count "ten," thus catching the water for only nine seconds. Make several trials. The quantities caught should agree among themselves within two per cent. after a little experience. Record the data in a set of columns headed "Nozzle diameter," "Counterweight," "Counterweight arm," "Gm. water discharged in 10 secs.," "Average gm. water discharged per sec.," and set down,

corresponding to the first entry in each of the first three columns, all the measurements of the quantities caught in ten seconds, and the average of these measurements divided by ten. "Counterweight arm" means the distance from the knife-edge to the point where the counterweight hangs. The notches are accurately 1 cm. apart, and the nearest one is accurately 3 cm. from the knife-edge. Now change the amount or position of the counterweight, or use a different nozzle, make the adjustment of the stream required for equilibrium of the vane, and obtain additional sets of data as before. One more measurement will be needed: the distance from the knife-edge to the center of the base of the funnel, where the stream strikes.

To work out the results, add another column headed "Force to stop stream (in gm. wt.)" and calculate this quantity as the unknown in the equation

"Counterweight times counterweight arm equals X times distance from knife-edge to centre of base of funnel."

Add another column headed "Speed of stream" and calculate this quantity as the quotient of the number of cc. of water discharged per second by the cross-sectional area of the nozzle in sq. cm. (Note that the number on the nozzle is its internal *diameter* in *inches*.) Add another column headed "Momentum lost per sec." and calculate this quantity as the product of "Speed of stream" by "Average gm. water discharged per sec." Lastly add a column headed "g" and enter there the quotient of "Momentum lost per sec." by "Force to stop stream (in gm. wt.)."

III. *A step-by-step development of the Second Law of Motion.*

For those wishing a more elaborate set of experiments with the apparatus, reference is made in this article on pages 771-773 of this issue, in which is outlined the step-by-step development of the Second Law of Motion as used at the Southern Branch of the University of California.

IMPORTANT ANNOUNCEMENT.

The Mathematics Section of the Missouri State Teachers' Association is assured of a very strong program for its meeting, November 16.

Dr. Eula Weeks, of the Cleveland High School, St. Louis, Mo., will tell "How to Make Effective the Work of the National Committee on Mathematical Requirements." The work of this committee has already been epoch-making in the teaching of secondary mathematics. The final report of the committee is an invaluable publication in the hands of teachers because of the value in the study of this, the result of the combined efforts of teachers of mathematics throughout the country. As

a member of the committee, Miss Weeks will have valuable suggestions to offer the teachers.

Professor Wm. A. Luby, of the Junior College, Kansas City, Mo., will discuss "The Real Problems of Education." Mr. Luby believes that in the educational turmoil of recent years some vitally important fundamentals have been, in part at least, overlooked. As an experienced teacher and also as an author of popular texts, Mr. Luby will have a message that no wide-awake teacher will care to miss.

Mr. R. L. Short, Principal of the Ames School, St. Louis, Mo., will give and address on "Preparing Pupils for High School Mathematics." Mr. Short says that the teaching of arithmetic fails largely through lack of interest on the part of the pupil. He is taught to mechanically perform the four fundamental operations and to struggle with fractions. Consequently, seventh and eighth grade teachers are spending valuable time teaching fundamental operations, and they are incidentally killing all liking for mathematics. All this because the pupil is not able to use his numbers.

A remedy for this is to arouse interest by making a study of the system. The beauties of number can be shown through comparison, classification, factors, and decimals.

Mr. Short will have a message of great value not only to the class-room teacher, but also to the administrator.

The meeting will be open to the discussion of these topics. Every teacher is urged to come prepared to enter into the discussion, and to help to make this a memorable meeting. All phases of the subject will be represented from early grades to college.

THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The twenty-second meeting of the Central Association of Science and Mathematics Teachers will be held at the Hyde Park High School, Chicago, Illinois, December 1 and 2, 1922.

A program unusually strong in the prominence of its speakers, and in the wide range of interest covered, is offered for both the general and sectional meetings. Professor Theodore Soares, of the University of Chicago, noted for his appealing eloquence, will speak on the "Social Values in the School Curriculum." Dean M. E. Haggerty of the University of Minnesota, one of the foremost authorities in the country on educational measurements, will discuss the "Place of Measurement in the Solution of Educational Problems in High School Science and Mathematics." Professor Otis W. Caldwell, the noted head of the Lincoln School, New York City, will deliver three addresses. And Professor John M. Coulter, of the University of Chicago, is so widely known and appreciated that every one will want to hear him on "Changing Ideals in Science Teaching." Teachers from the high school class-room will discuss methods and progress in their own work before the various sections. There is literally a feast of good things for every teacher of science and mathematics.

The social interests of the members and their guests have not been overlooked. Abundant opportunity will be given for gaining information and inspiration from friendly personal conferences with teachers from various parts of the country.

This is the twentieth anniversary of the organization of the Association. Come to the meeting with a determination to make it a conspicuous milestone in the history of the organization. Help us to lead

in educational progress as we have done in a conspicuous way during the past two decades.

Every teacher of science and mathematics owes it to himself and to his fellows to support teachers organizations. Help make this Association what you think it ought to be. If you are a member, get a new member.

The railroads are offering special rates. Watch for the year book. Make your plans early to attend the meeting.—[*Alfred Davis, President. Soldan High School, Saint Louis, Mo.*

AN IMMENSE DEPOSIT OF MAGNESITE IN SOUTHERN NEVADA.

A massive deposit of magnesite of unusual character that has recently been brought to the attention of the United States Geological Survey promises to yield a large and readily available supply of this material. The deposit lies in Clark County, Nev., in the valley of Muddy River, one of the tributaries of Virgin River, a few miles above the town of St. Thomas. The material has been known for some time as kaolin, and successful experiments for utilizing it as a porcelain clay are reported to have been made, though they have not yet resulted in the exploitation of the deposit. The recognized outcrops have been located as mining claims, and some preliminary exploration and development work has been done. A side track on the St. Thomas branch of the Los Angeles & Salt Lake Railroad, about 3 miles northeast of the northernmost group of claims, offers a readily available railroad connection, and the station has been named Kaolin from this deposit.

The so-called kaolin is stated by the Geological Survey to be in fact a magnesite and was deposited in a highly magnesian sedimentary bed, a part of a regularly stratified series of sedimentary beds exposed by stream channels that cut across a low ridge at the upper edge of Muddy Valley. The deposit forms a chalky-looking bluff, dazzling white in the bright sunlight. The material is porcelain-white, fine grained, and massive, is remarkably free from foreign material, and has the structureless appearance and conchoidal fracture that are generally characteristic of magnesite. It is not so hard as the more typical magnesite, and it crumbles more rapidly on exposure to the weather.

The deposit is included between tilted beds of conglomerate and sandstone below and shale above. The lower contact is sharply defined, but the magnesite grades up into the overlying beds. The purer part of the deposit consists of beds aggregating at least 200 feet in thickness. Within the section of purer material there are a few bands of sandy matter, but these are minor in amount and apparently almost negligible, as they could undoubtedly be avoided in mining. The whole section lies in the form of a "hogback"—that is, the softer beds lap up against a uniform slope of the sandstone and conglomerate that has a northeasterly dip of 30° to 50°.

THE CREST OF THE SIERRA NEVADA.

The highest point in the United States, Mount Whitney, is not an isolated mountain peak like Mount Shasta or Mount Rainier, which are old volcanoes, but is a summit in the great tilted block of the earth's crust, forming California's sawtooth range, the Sierra Nevada.

One stormy day early in the seventies the first Director of the Geological Survey, Clarence King, laboriously, amid cloud and fog, climbed to the top of Mount Whitney, as he supposed, only to find, long afterward, that he had really climbed a neighboring peak. By a second journey,

however, made two years later on a clear day, he reached the summit of the true Mount Whitney. "The Sierra here," says Mr. King, "is a bold wall with an almost perpendicular front of about 3,000 feet, which is crowned by sharp turrets having a tendency to lean out over the eastern gulf. These are properly the crests of great riblike buttresses which jut from the general surface of the granite front. Mount Whitney itself springs up and out like the sharp prow of an ocean steamer. Southward along the summit is a region of confused rough-hewn granite oblisks and towers, all remarkable for the deep shattering to which the rock has been subjected. It is a region which may even yet suffer considerable perceptible change, since a single winter's frost and snow must dislodge numberless blocks from the crests and flanks of the whole group. Indeed, at the time of my visit, notably the period of least snow and frost, we often heard the sharp rattle of falling debris."

The top of Mount Whitney stands 14,501 feet above sea level. Among mountains of slightly less height, none of them more than six miles distant from Mount Whitney, are Mount Russell, 14,190 feet; Mount Williamson, 14,384 feet; Mount Muir, 14,025 feet; Mount Langley, 14,042 feet; Mount Barnard, 14,003 feet; and Mount Tyndall, 14,025. feet

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LOOTING CHURCHES.

"Russian churches are not the first to have their wealth requisitioned by conquerors or those in power," says a bulletin from the Washington, D. C., headquarters of the National Geographic Society, in commenting upon the recent step of the Soviet Government in compelling priests and monks in Russia to hand over gold church vessels and other valuables.

"The convenient masses of treasure held by some churches in Christendom, and pagan temples in many lands," continues the bulletin, "have ever been strong temptations to those who frankly looted as well as to the more dignified if equally efficient 'requisitioner' and the 'fixer of indemnities.'

World Famous Gems From Temples.

"The ancient Egyptians and the Babylonians sacked the temples of their enemies, probably for the benefit of the kings' treasuries. Indian history tells of rich temples thrust into poverty by conquerors, grown again to wealth and again the victims of another victor. Some of these are wealthy again today, their idols gazing out through eyes fashioned from flawless precious stones, worth the ransom of an emperor. One of the most famous diamonds in the world, the Orloff, which formed the tip of the scepter of the Russian Tsar, is believed to have been gouged from the forehead of an Indian idol nearly two centuries ago by a European soldier of fortune.

"Everyone knows how Emperor Titus on the capture of Jerusalem sacked Solomon's temple and took away the famous seven-branched candlestick. It is not so well-known that when the Mohammedan Saracens invaded Rome in 846 they looted St. Peter's Church carrying away much treasure. Even as early as 800 this church had 1,500 pounds of gold ornaments.

Crusaders Looted Churches.

"Church treasure has been taken, too, by factions within Christendom itself. After the separation of the Western and the Eastern churches, the army of the Fourth Crusade, made up of Latins, sacked Constantinople and took much treasure from the famous church of Sancta Sophia.

In 1453 the Turks captured Constantinople and subjected this great church to its final looting.

"Dutch churches lost their valuables when their country was conquered by Spain; many gold and silver vessels were seized during the Reformation in England and in continental countries; and at the height of his power Napoleon subjected the Vatican treasury to very heavy indemnities.

"The precious metals and the precious stones have played a part in religious observances as far back as history reaches. But the services of the Christian Church, during its early days, were conducted with the greatest simplicity. This was largely because persecution forced secrecy and this in turn made for simplicity. When the church received official recognition near the close of the third century, however, the tendency toward ornamentation and enrichment soon asserted itself. Especially was there a tendency toward the making of gifts to churches by pious church members and powerful patrons. Constantine, first Christian emperor of Rome, lavished gifts on the church of St. Peter, and later on Sancta Sophia, in his new capital Constantinople. He thus had a hand in the enrichment of the two most famous, and once the two richest churches in Christendom.

Tons of Gold and Pounds of Gems.

"The movement toward the enrichment of churches spread rapidly and was very marked by the sixth century. Altars of solid gold and of solid silver were presented to some churches. Golden chalices and plates, some of them gem-studded, came into use; and many golden images, canopies, fonts, candelabra and other articles of precious metal were placed in the churches. Later only wood and stone were permitted for the actual altar, but altar-fronts of gold continue to be used and most sacred vessels are still made of that metal.

"When the court of the then semi-civilized Russia sent out envoys in 987 to choose a religion for the country, they were most impressed by the services in Sancta Sophia, largely because of their elaborateness and display of wealth. From that time the Russians have shown a tendency toward the rich embellishment of their churches. Their ikons and sacred vessels are not only largely of gold, but many of them are literally covered with gems. In late years Russian church treasuries have been among the richest in existence. Screens, reliquaries and canopies of precious metals were to be found in all of the well-to-do churches. In some of the richer institutions whole walls of sanctuaries were of silver and some floors were of jasper. Some of the palls used were practically small rugs of gems, worth a fortune.

"Probably the wealthiest of all religious institutions in Russia, and among the wealthiest in the whole world, was the Lavra, or super-monastery, at Kiev. Before the World War it had an annual income of half a million dollars and a well-stocked treasury. The second most important institution, the Lavra of St. Sergius, near Moscow, had treasure with a pre-war value of about $325,000,000. At the Cathedral of St. Isaacs, St. Petersburg, there was more than a ton of silver in the form of ecclesiastical vessels, and in addition much gold."

PROBLEM DEPARTMENT.

Conducted by J. A. Nyberg,

Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1039 E. Marquette Road, Chicago.

SOLUTION OF PROBLEMS.

746. *Proposed by J. David Weintraub, Newport, Ky.*

AB is the diameter of a circle; C and D are its trisection points in the order A, C, D, B. E and F are points on the circle such that arc BE = arc BF = 60°. Prove that the circle drawn through E, D, and F trisects the minor arcs of all the circles which have AB as a chord.

Solution by J. F. Howard, Brackenridge H. S., San Antonio, Tex.

In the figure, K is the center of the circle through E, D, F; and L is the center of circle ASB. $OL \perp AB$. $EH \perp AB$. The theorem as proposed states that arc BS = 1/3 arc BA.

This, however, is not true.

Let AB = 6; then EB = 3, HB = 3/2, EH = $3\sqrt{3}/2$.

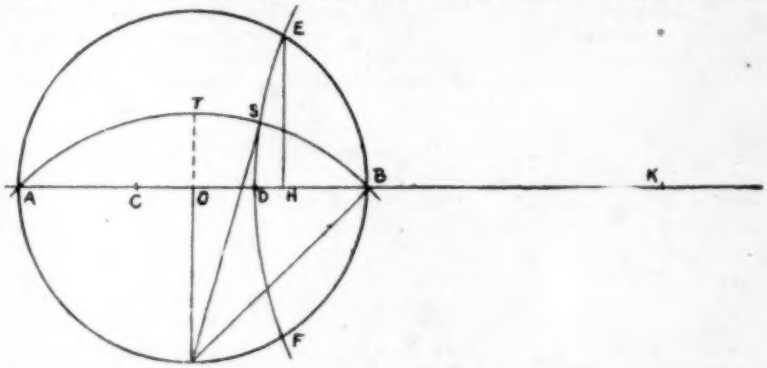
Also $DH(2DK-DH) = EH^2$, whence DK = 7; OK = 8.

The equation of circle EDF, referred to rectangular axes through O is

$$(x-8)^2+y^2 = 7^2. \tag{1}$$

The equation of circle ASB is $x^2+(y+3)^2 = 18$. (2)

Let coordinates of S be $x = m$, $y = n$. Then $\tan \angle SLT = m/n+3)$; but since $\angle SLT = 15°$ (*if* S is a point of trisection), $\tan \angle SLT = 2-\sqrt{3}$; or $m/(n+3) = 2-\sqrt{3}$ which may be changed into $n+3 = m(2+\sqrt{3})$. But m and n must satisfy equations (1) and (2), and the equation found



by subtracting (1) from (2). This gives $8m+3n = 12$ which does not agree with $n+3 = m(2+\sqrt{3})$. Hence $\angle STL$ is not 15°.

Further, if the center of the circle ASB is taken at $(0, -k)$, $\angle SLT$ will not be 1/3 of $\angle BLT$ except for values of k given by a cubic equation.

Similarly solved by *Norman Anning, Ann Arbor, Mich.*, who also pointed out that, using the same numerical values as above, the circles intersect at (1.087, 1.101) whereas the point of trisection of the arc BA is $x = \sqrt{18}\sin 15°$, $y = \sqrt{18}\cos 15°-3$, or (1.098, 1.098). Several readers pointed out that the theorem could not be true for then we have a construction for trisecting an angle, which is impossible. The interesting part, however, is in disproving any particular construction.

747. *Proposed by Elmer Schuyler, Bay Ridge H. S., Brooklyn, N. Y.*

Let AB = 1. Extend AB to C making BC = side of a regular decagon inscribed in a circle of unit radius. On AC as a diameter, draw a semicircle, and let the perpendicular to AC at B intersect it at D. Show that $2(BC+AD)/3$ is approximately $\sqrt[3]{2}$. (*Boccali's* method.)

Solution by G. H. Crandall, Culver Military Academy, Culver, Ind.

$BC = (-1+\sqrt{5})/2$. $AD^2 = AC \times AB = 1+BC = 1.618034+$ or $AD = 1.27202$. Then $2(BC+AD)/3 = 1.26003$. But $\sqrt[3]{2} = 1.25992$.

Also solved by *W. C. Eells, Whitman College, Walla Walla, Wash.; J. F. Howard; Smith D. Turner, Andover, Mass.; and Henry L. Wood, Boonton, N. J.*

A comparison of the various methods for approximating the value of $\sqrt[3]{2}$ is stated below, by *Walter C. Eells.*

702.	(See November, 1921)	$\sqrt[3]{2} = 1.25977$	Error $-.00015$
727.	By *Buonfalce*	$\sqrt[3]{2} = 1.25991$	$-.00001$
732.	By *Peraux*	$\sqrt[3]{2} = 1.25928$	$-.00064$
747.	By *Boccali*	$\sqrt[3]{2} = 1.26003$	$+.00011$

Elmer Schuyler mentions another method, also due to *Buonfalce:* Construct a unit square ABCD. Divide the diagonal DB into 6 equal parts. On DA lay off DE = DB/6. Then BE approximates $\sqrt[3]{2}$ to within one thousandth of an inch.

748. *Proposed by Norman Anning, Ann Arbor, Mich.*

Show that, excluding trivial cases there are 62 polynomials with integral coefficients by which $x^{12}-1$ may be divided without remainder.

Solution by L. E. Lunn, Heron Lake, Minn.

$$x^{12}-1 = (x^6+1)(x^6-1) = (x^2+1)(x^4+x^2+1)(x^2-1)(x^4-x^2+1)$$
$$= (x^2+1)(x^2+x+1)(x^2-x+1)(x-1)(x+1)(x^4-x^2+1)$$

The number of individual factor is	6
By taking 2 at a time we obtain	15
By taking 3	20
By taking 4	15
By taking 5	6

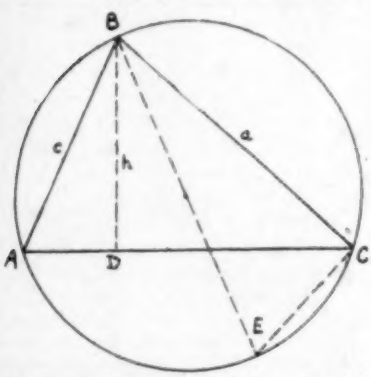
This makes 62 possible divisors in all. As all the 6 individual factors are different and prime, the 62 include all cases except when the product of all 6 factors is used as a divisor.

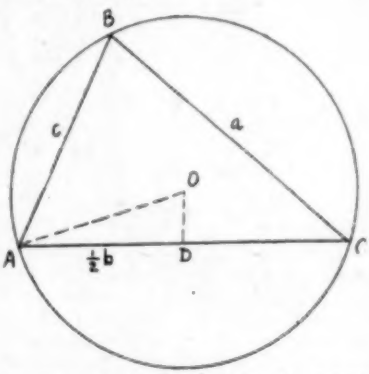
Also solved by *G. H. Crandall; Thomas E. N. Eaton, Redlands, Cal.; Michael Goldberg, Philadelphia, Pa.; J. F. Howard, and Edward Lewis, pupil, Redlands, Calif.*

749. *Proposed by John A. van Groos, Oregon Agricultural College, Corvallis, Ore.*

Without trigonometry prove that the area of a triangle of sides a, b, and c is $abc/4R$, where R is the radius of the circumscribed circle.

I. *Solution by W. H. Carnahan, Washington, Ind.*





Draw the altitude BD = h, and the diameter BE. Since triangles BDA and BEC are similar, $h/a = c/2R$ or $h = ac/2R$. The area of $\triangle ABC = bh/2 = abc/4R$.

(*Continued on page 784.*)

IS YOUR LIBRARY ORGANIZED FOR EDUCATION?

The American Library Association believes that every student from the elementary school through the university should learn to use and appreciate books and libraries, not only that he may study to advantage in school, but also that he may continue through adult life to benefit from the resources of libraries.

To accomplish this there should be a supervisor of school libraries in every state and province, and a school librarian or supervisor for every school system—city, county, township or district.

We, therefore, recommend as a minimum standard that there be at least one full-time school librarian for an enrollment of 1,000 elementary and high school pupils.

Whether the school library supervisor or librarian shall be employed by school or library authorities, separately or jointly, is a matter to be determined by state or local conditions.—[*American Library Association, Chicago, Illinois.*

ORGANIZATION OF THE SCIENCE SECTION OF THE ASSOCIATION OF COLLEGES AND PREPARATORY SCHOOLS OF THE MIDDLE STATES AND MARYLAND.

At the annual meeting of the Association of Colleges and Preparatory Schools of the Middle States and Maryland, held at Swathmore College on Saturday, November 26, 1921, a Science Section was organized. Dr. Bertha M. Clark, Wm. Penn High School, Philadelphia, presided at the organization meeting. A constitution, prepared by a committee consisting of Dr. H. J. Creighton, Swathmore; Dr. James Barnes, Bryn Mawr; Dr. Ida A. Keller, Philadelphia High School for Girls; Dr. W. B. Meldrum, Haverford; and Dr. R. H. True, University of Pennsylvania, was presented and adopted by unanimous vote.

According to its constitution the Science Section has been organized to bring about active cooperation between the colleges and preparatory schools in improving the teaching of science. The program of the day made a splendid beginning towards realizing this cooperation. Dr. W. J. J. Bliss, Johns Hopkins University, presented the college point of point in regard to "Desirable and Possible Modifications of College Entrance Requirements in Science." The High School side of the question was presented by Mr. C. E. Dull, of Newark, N. J., and Miss Elmira Lodor, of Kensington High School, Philadelphia.

The following officers were elected to serve one year: President, Dr. Thomas D. Cope, Randal Morgan Laboratory of Physics, University of Pennsylvania; Vice President, Mr. Charles E. Dull, South Side High School, Newark, N. J.; Secretary, Miss Margaretta Atkinson Philadelphia High School for Girls; Treasurer Dr. Walter Steckbeck Macfarlane Hall of Botany University of Pennsylvania.

The following Councillors were elected to serve two years: Dr. Gellert Alleman Swathmore College; Dr. Bertha M. Clark William Penn High School Philadelphia; Dr. Raymond Brownlee, Stuyvesant High School, New York City.

The council has decided to hold the next meeting of the section at the time of the next annual meeting of the Association of Colleges and Preparatory Schools. This meeting will be held at the Tower Hill School, Wilmington, Del., during the 1922 Thanksgiving recess. An attractive program is being prepared and plans are being made to materially increase the membership of the section. Due announcement of the program will be made public.

Similarly solved by *G. H. Crandall; Thomas E. N. Eaton; J. B. Faught, Yankton College, Yankton, S. Dak.; J. F. Howard; R. T. McGregor, Elk Grove, Calif.; Smith D. Turner; Henry L. Wood;* and *Richard Slauer, pupil, Dickinson H. S., Jersey City, N. J.* The *proposer* and *Michael Goldberg* presented an original solution; or, at least the Editor has never seen it before.

II. *Solution by the Proposer.*

Join the center of the circle to A and C; draw $OD \perp AC$; since $\angle B = \angle AOD$, we may apply to $\triangle$sABC and AOD the theorem: If two triangles have an angle of one equal to an angle of the other, the ratio of their areas equals the ratio of the products of the sides including this angle. Hence

$$\triangle ABC / \triangle AOD = ac/R \times OD; \text{ but } \triangle AOD = 1/2\,b \times 1/2\,OD$$

Hence $\triangle ABC = abc/4R$.

To a teacher of geometry this proof is interesting as an application of the theorem stated above. The only other application of it, in fact the only reason for its existence in text books, is as a preparation for the theorem: Similar triangles are to each other as the squares of corresponding sides.

750. *For high school students. Proposed by the Editor.*

In a 10 mile race, A can beat B by 2 miles, and A can beat C by 4 miles. By how many miles can B beat C?

The best solutions (2 1-2 miles) were written by *F. Halsted Sillick, Boonton, N. J.*, who solved the problem graphically showing how far each man had gone in fractional parts of n hours, and by *Edw. Lewis, Redlands, Cal.* In the other solutions, the answers were correct but the explanations were poor. In his explanation of a simple problem the pupil shows that it is more difficult to explain a problem than to find merely the answer. That we may profit by the errors of others, two explanations (poor ones) are shown below, exactly as written.

I. If A can run 10 mi. in x time, B can run ten mi. in $10x/8$ time. C can run one mi. in $x/6$ time.

$10x/8$ will be the time given C to run.

$10x/8 \div x/6 = 10x/8 \times 6/x = 7\,1/2$

$7\,1/2 \times 1 = 7\,1/2$ mi.

C can run 7 1/2 mi. in $10x/8$ time.

B can beat C by 2 1/2 mi.

II. Let A = rate of first man
B = rate of second man
C = rate of third man

A : B :: 10 : 8 A : C :: 10 : 6 B : 6 :: 8 : 6

6B = 8C B = 10 C = 7.5

10 − 7.5 = 2.5

B can beat C by 2.5 miles.

If we insist in a geometry class that it is worth while to think carefully and to avoid loose reasoning, why not start the good work in the algebra class? The teacher who insists on clear explanations in an algebra class will find he is making the work easier for himself next year in his geometry class.

PROBLEMS FOR SOLUTION.

761. *Proposed by R. T. McGregor, Elk Grove, Calif.*

If m and n are positive integers, show that the product $2mn(m^4 - n^4)$ is a multiple of 60.

762. *Proposed by Fred A. Lewis, University, Ala.*

If (ab) means the angle measured from line a to line b, and a, b, c, d are four concurrent lines, prove that

$$\sin(ac) \cdot \sin(bd) = \sin(ad) \cdot \sin(bc) + \sin(ab) \cdot \sin(cd)$$

763. *Proposed by F. A. Cadwell, St. Paul, Minn.*

Without using the *reductio ad absurdum* method, show that if the sum of two opposite sides of a quadrilateral is equal to the sum of the other two sides, a circle may be inscribed in the quadrilateral.

764. *Proposed by Henry L. Wood, Boonton, N. J.*

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Assuming the possibility of drawing the trisectors of angle A of $\triangle ABC$, cutting BC in points D and E, prove that

$$AB^2/AC^2 = BD \times BE/EC \times DC.$$

765. *For high school students. Proposed by Elmer Schuyler, Bay Ridge High School, Brooklyn, N. Y.*

Explain the error in the following proof:

Given two triangles ABC and A'B'C' with AB = A'B', AC = A'C' and $\angle ABC = \angle A'B'C'$.

Prove that $\triangle ABC$ equals $\triangle A'B'C'$.

Place A'C' on AC so that B and B' fall on opposite sides of AC. Join B to B'. Then $\angle ABB' = \angle AB'B$ because AB = AB'; and $\angle ABC = \angle AB'C$ by the hypothesis. Hence, by subtraction, $\angle CBB' = \angle CB'B$ which leads to CB = CB' = C'B'. And the two triangles are equal, having 3 sides of one equal to 3 sides of the other.

SCIENCE QUESTIONS.

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School examinations are particularly desired.

Newspaper items contain many interesting problems—frequently much pseudo-science. Send them in.

Acknowledgments.

The receipt of examination papers is gratefully acknowledged from: The University of Melbourne, Melbourne, Australia; and the Education Departments of New South Wales, New Zealand, West Australia, and Queensland.

Mr. John Lundberg, Godeborg, Sweden, has again sent in a set of *Uppgifter i fysik.*

Inquiries concerning physics and chemistry tests have been received from Soochow University, Soochow, China, and from the Province of Surigao, Philippine Islands.

PROBLEMS AND QUESTIONS FOR SOLUTION.

396. *Where is the fallacy, if any, in this advertising stunt?*

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EXAMINATION QUESTIONS.

The following examination papers are from the Province of Quebec, Protestant Education Committee.

397. *An expression of opinion concerning them would be appreciated by the Editor.*

Please send in an answer to question numbered 398.

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Hygiene—Grade VI—Superior School Examinations, Quebec.

Wednesday Afternoon, June 15, 1921, from 2 to 4.

(*Answer any eight questions.*)

1. Explain briefly what was done to stamp out malaria fever in the Panama Canal Zone, and show what results followed.
2. What is the principal difference between pure air and air that has been breathed? What is meant by ventilation?
3. Why do people need sleep? Under what conditions will a person get most good out of sleep?
4. What organs are concerned in respiration? Describe briefly each of these organs.
5. Why should a person breathe through his nostrils? What are adenoids and what evil results follow their presence?
6. "Fine head work and coarse stomach work make a poor combination." Explain and enlarge upon this statement.
7. Into what three classes are foods divided? Describe each class and give examples.
8. What effects follow the use of tobacco by boys? Why should its use be discouraged?
9. Explain carefully the uses of the white corpuscles in the blood in disease.
10. Tell something about the proper care of milk in the house.

Nature Study and Agriculture.—Grade VI.—Superior School Examinations, Quebec.

Tuesday Afternoon, June 14, 1921, from 2:45 to 4.

(*Answer only six questions. Questions of equal value.*)

1. Describe carefully a bean-seed and a pea. What are monocotyledons and dicotyledons?
2. How do plants use water? How many acres are there in a field 40 rods long and 24 rods wide?
3. Tell what you know of ammonia, carbon dioxide, potash, iron oxide, and nitrogen.
4. Describe how soils are made. Name five agencies in soil formation.
5. Explain carefully some of the ways that soil fertility may be retained in farming.
6. What is meant by tillage? How does water rise through the soil?
7. What is meant by crop rotation? Give an example of one that continues for five years.
8. Into what two classes may insects be divided? How may these be controlled?
9. Into what classes may weeds be divided? Describe each class and give one example of each.

Grade VII.

(*Answer any six questions for a full paper.*)

1. Describe, with examples, the different classes of foods.
2. Explain how cows, corn, and clover form a good combination for the farmer.
3. What are the principal products of the dairy? Discuss the relative merits of each from the point of view of soil exhaustion.

398. A farmer has two cows, one supplying 986 lb. of milk, testing 3.1% butter fat in a certain month, and the other 812 lb. testing 4.2%. If the creamery allows him 27 cents a pound for butter fat, which cow pays him the more for that month, and how much more?

5. Write briefly on the care of poultry and best food for poultry.
6. What is the best soil for potatoes? What yield may one expect per acre? How should the soil be prepared?
7. What is a silo? Tell something about its construction and its use.
8. What is meant by landscape gardening? Give some directions for tree planting.
9. What causes rust, blight, smut, and rot on plants? How do these diseases spread?

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BOOKS RECEIVED.

Prints of Human Geography, by Ellsworth Huntington, Yale University, and Sumner W. Cushing, Normal School, Salem, Mass. Pages XIV plus 430. 16x24½ cm. 1922. Cloth. $3.50. John Wiley and Sons, New York City.

An Introduction to the Graphic Language, by G. C. Anthony, Tufts College. Pages VII plus 166. 16x20 cm. Cloth. 1922. D. C. Heath & Co., Chicago.

The Expert Typist, Clarence C. Smith, Washington Business High School. Pages xiii plus 274. 14x20½ cm. Cloth. 1922. Macmillan Co., New York.

Live Stock and Farm Mechanics, by John H. Gehrs, Missouri State Teachers' College. Pages viii plus 393. 14½x19 cm. Cloth. 1922. Macmillan Co., New York.

Industrial Physics Mechanics by L. R. Smith, Dickinson High School, Jersey City. Pages xi plus 226. 13x19½ cm. Cloth. 1922. McGraw-Hill Book Co., New York City.

Problems in American Democracy, by Thames R. Williamson, Smith College. Pages xv plus 567. 14½x20 cm. Cloth. 1922. D. C. Heath & Co., New York City.

Junior High School Mathematics by E. H. Taylor, and Fiske Allen, Eastern Illinois Normal School. Pages x plus 149. 13x19½ cm. Cloth. 1922. Henry Holt & Co., New York City.

Forty Notifiable Diseases, by Hiram Byrd, University of Alabama. Pages v plus 74. 13x18½ cm. Paper. 1922. 60 cents. World Book Company, Yonkers, New York.

Fector Calculus, with Applications to Physics, by James P. Shaw, University of Illinois. Pages v plus 314. 14½x20½ cm. Cloth. 1922. $3.50 net. D. Van Nostrand Company, New York City.

Elements of Astronomy, by D. N. Mallick, Fellow of the Calcutta University. Pages viii plus 233. 15x22½ cm. Cloth. 1921. Cambridge University Press.

Farm Projects for the Seventh and Eighth Grades, by Carl Calvin, and John A. Stevenson. Pages x plus 363. 15x19 cm. Cloth. 1922. The Macmillan Company.

College Algebra, by Walter B. Ford, University of Michigan. Pages vii plus 262. 13x19½ cm. Cloth. 1922. Macmillan Company.

Easy Experiments in Elementary Science by Herbert McKay. 144 pages. 12½x18½ cm. Cloth. 1922. 50 cents. Humphrey Milford Oxford University Press, London, England.

The Federal Board for Vocational Education, by W. S. Holt. Pages xi plus 74. 15x23 cm. Cloth. 1922. D. Appleton & Company.

High School Geography, by R. H. Whitbeck, University of Wisconsin. Pages x plus 577. 14x20½ cm. Cloth. 1922. The Macmillan Company, New York.

Elements of Projective Geometry, by George H. Lin, George Wentworth, and David Smith. Pages vi plus 186. 15x21½ cm. Cloth. 1922. $2.80. Ginn and Company, Boston.

The Smithsonian Institution Report for 1920. 704 pages. 16x23½ cm. Cloth. 1922. Government Printing Office, Washington.

Elementary Calculus, by Frederick S. Woods and Frederick H. Bailey, Massachusetts. Pages viii plus 318. 14½x21½ cm. Cloth. 1922. $3.00 Ginn and Company, Chicago.

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BOOK REVIEWS.

The Federal Board for Vocational Education, by W. S. Holt. 15x23 cm. Cloth. 1922. D. Appleton & Co.

A valuable book for those who are interested in vocational education. There is a short history of this phase of education given, which is to the point and contains all of the high phases of vocational history. There is a chapter on organization, something to say with reference to the vocational board of education, and it has a summary of the publications of this department, and also an outline of the laws passed by Congress on the subject. A very complete bibliography of the subject is given. It is well indexed. C. H. S.

High School Geography, by R. H. Whitbeck, University of Wisconsin. Pages x plus 577. 14½x20½ cm. Cloth. 1922. The Macmillan Company, New York City.

With question this is one of the most valuable books on high school geography that has come from the press during recent years. All geographers know something of the high caliber and the educational attainments of Dr. Whitbeck. Any writing that has his name attached to it must of necessity be authoritative.

Perhaps the two most important facts that the author emphasizes are that secondary school geography ought to be humanized and also the influence of geographical environment upon man's mode of life. Indeed, these two phases of the book are well brought out in the discussion.

The book is divided into two parts. Part one consists of twenty chapters and 424 pages. The book is profusely illustrated, there being 383 half-tones and maps, all selected for the story they are to tell. There are eight maps in color. The book covers the earth. Major paragraphs begin with bold-faced letters stating the nature of the discussion in this paragraph. Each chapter closes with a list of very practical exercises bearing upon the things discussed in that chapter.

The diction and description are fine. The high school pupil will have no difficulty in understanding what the author says.

It is a book that deserves and doubtless will have a large circulation. Teachers and boards of education looking for the adoption of a geography text cannot do better than to select this one. C. H. S.

Radium Star Map.

The Radium Star Map Published by E. W. Sundell, Oak Park, Illinois.

This is really something new in the line of school maps and apparatus. It is a large chart of the stars, about 125 centimeters long and thirty centimeters wide and is mounted on heavy cardboard divided into four sections, strongly hinged for convenient folding. On one section are the circum-polar stars which appear to turn in the opposite direction to a clock. On the remaining sections are shown stars from the zenith to the southern horizon, which rise and set as our sun does. The map shows all of the stars of the first four magnitudes, the constellations are indicated and the names of the principal stars given. The stars and the connecting lines are marked with a radium compound, making them shine at night.

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Under this heading are published in the March and November issues of this Journal the names and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officiary of their society. This is extremely valuable information to all progressive teachers. Is your society listed here? Names are dropped when they become one year old.

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